THE ACQUISITION OF THE CONSERVATION OF NUMBER BY PRESCHOOL CHILDREN USING DIDACTIC AND ALTERNATIVE EXAMPLE METHODS OF INSTRUCTION TO EXAMINE APTITUDE X TREATMENT INTERACTION

By

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Dedicated To

Mary Jane, Wes, Molly, Katie, Tom and [illegible]

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Major Department: Curriculum and Instruction

The purpose of this study was to examine the presence of conservation aptitudes in subjects determined to be in the Piagetian preoperational stage and, secondly, examine conservation performance using an Aptitude x Treatment Interaction (ATI) model in which the differential effects of impulsivity, reflectivity and verbal ability were examined in relation to Didactic and Alternative Example methods of instruction. It was expected that the treatment conditions would influence the conservation performance of the preschool children. Furthermore, it was anticipated that learner characteristics would interact significantly with treatment conditions.

Thirty subjects were randomly assigned to one of three treatment groups. Subjects were administered aptitude tests representing impulsivity-reflectivity, verbal and full scale IQ in addition to treatment materials and pretest, posttest performance measures. The pretest, posttest measures were designed to indicate conservation of number performance and acquisition.

Comparison of performances on posttest scores indicated a strong significant F ratio where conservation performance had been altered by the treatment conditions. Using an analysis of covariance technique, it was found that there was no interaction between impulsivity-reflectivity and treatment. However, when the categorical variables of impulsivity-reflectivity were removed and the continuous variables of latency score and error score viewed a significant interaction appeared between treatment and aptitude. These data suggested that impulsive students performed significantly better in the Verbal Didactic method. The verbal and full scale aptitudes did not intersect significantly with either treatment although they were significantly correlated with the criterion scores.

CHAPTER I

THE PROBLEM

Statement of the Problem

The focus of this study is the diagnosis of the presence of conservation aptitudes in subjects determined to be in the Piagetian preoperational stage and, the examination of conserving performance of preschool children (Ages: 3.0 - 5 8) using an Aptitude x Treatment Interaction (ATI) model in which the differential effects of impulsivity, reflectivity and verbal ability are examined in relation to Didactic and Alternative Example methods of instruction.

Background to the Problem

Piaget (1952) has demonstrated that the ability to conserve is a prerequisite to successful learning of mathematical and scientific concepts. The ability to conserve is only one of Piaget's many concepts that has been studied extensively. It is said that "conservation can be best defined as the ability of an individual to be aware of the invariant aspects of the properties of objects in the face of transformation". (Sigel & Hooper, 1968, p. 62) Conservation of number was,

area and volume are but a few areas in which research has been conducted. Of these, conservation of number has been stated as primary to the acquisition of additional mathematical and scientific concepts.

Scientific thinking would be impossible without the principle of conservation. The recognition that a given quantity remains constant through transformation in number, shape, size, arrangement, mass and energy are the foundations on which much of modern science is built. The importance of the idea of conservation and the growth of logical thinking in children was recognized by Piaget who states his views as follows:

> Every notion, whether it be scientific or merely a matter of common sense presupposes a set of principles of conservation, either implicit or explicit. Obviously, conservation, which is a necessary condition of all experience and reasoning, by no means exhausts the representations of reality. Our contention is merely that conservation is a necessary condition of all rational activity. (Piaget, 1962, pp. 281)

Because of the primacy of this principle in the growth of logical thinking, there has been a continual interest in the experiment, which Piaget has performed to explore children's thinking about problems of conservation. Piaget's work in this area has been of particular interest to those concerned with science education for children because the concept of conservation is basic to the formulation and growth of scientific concepts.

Related Theory and Research

Overview of Piagetian Theory

Jean Piaget, a Swiss born psychologist, is one of the foremost theorists in child development today. Piaget has formulated a scheme representative of the cognitive intellectual development of the child through a sequence of stages which appear at about the same age in each child. While the order of these periods is fixed for all children, an individual's time-table for entering and leaving each period will vary to some degree. Within each period there are additional levels of cognitive development called stages or substages. A summary of Piaget's (1966) four general stages are as follows:

1. Sensori-Motor Stage - This is the period before the acquisition of language occurring from birth to two years. It is characterized by simple reflexes, beginning habits and elementary means--goals activity. The latter is accomplished by the coordination of vision and the ability to grasp objects and thus alter the immediate situation. The child explores the world from an egocentric point of view.

2. Preoperational Stage - From two to six years the child progressively refines his ability to initiate action

subsequent to his observing the situation. While child lacks conservation (the realization that certain quantities remain constant under simple transformations such as regrouping objects from one large concentration into a number of smaller groups), he uses objects and language to expand his spatial awareness. Objects and acts are still ego centered; explanations as to "why' are neither inductive nor deductive--the child reasons from the particular. The single most important characteristic of preoperations thought is the inability to mentally reverse a series of actions and realize that a martain series of actions can be "cancelled out' by their inverse series of actions

3. Concrete Operations Stage - In the period from seven to twelve years the child masters the concept of conservation and can perform logical operations with real objects subject to his manipulation. The concept of number, order (by size and weight), and classification are understood in this stage. The child's thought becomes reversible and he can structure the present in terms of the past

4. Formal Operations Stage - The final cognitive period is primarily characterized by the ability to reason about logical operations in an abstract fashion (Piaget, 1966).

It is difficult to classify Piaget's theory as to the importance of factors which effect maturation and experience. Individual researchers and particular studies have been critical of certain aspects of Piaget's developmental psychology (particularly the reference to age norm). The research summaries of Wallach (1964) and Flavell (1963), however, indicate general support for Piaget's theory of cognitive development. Wallach (1964) in reviewing the research and theory concerning children's thinking, focused on the work of Piaget and his colleagues. Drawing from a bibliography of 107 items, Wallach reported the confirmation of the basic outline of Piaget's stages. Some shifting of age norms are the function of socio-cultural status and language. Training in the concept of conservation has little or no effect on the ability of children to perform ahead of their present stage. There are qualitative differences in the thinking of children as they move from stage to stage and not merely more of the same modes of analysis. The construction of the ability to analyze the physical world is a slow, laborious process (Piaget & Inhelder, 1967, p. 22).

Flavell (1963) in assessing over forty studies concerned with Piaget's theory of cognitive development had these general impressions: The cognitive stages are not as bound as Piaget infers, but are also factors of intelligence and socio-economic background. These studies, failing to add much to Piaget's theory of qualitative cognitive change, have only enabled the researchers

...e make criticisms in areas chosen for investigation

The following authors have replicated some of the experiments from Piaget & Inhelder's book, The Child's Conception of Space (1948): Rose (1968), Dodwell (1963), Lovell (1959), Peel (1959) and Rivoire (1961). Dodwell (1963) was critical of Piaget for not indicating the generality of his findings between children of the same age and between different tests concerning the same spatial understandings. From the sample of 194 children in the age range of five to eleven drawn from all socio-economic levels, Dodwell reported results from seven experiments taken from The Child's Conception of Space. He concluded that on the whole Piaget's assertions about development of conservation concepts were corroborated, although not in all respects. Dodwell did not find it possible to categorize very many of his subjects into one particular phase of development. In all seven experiments the majority of his subjects were found to have characteristics of at least two of Piaget's four stages (cited earlier in this chapter). He did not use Piaget's substages. Dodwell suggested that some of these difficulties might be attributable to "special interest and training, amount of formal instruction and the difficulties of learning to apply a set of rules or operations learned in one context to a new situation". (p. 141) This same researcher concluded that the child's overall ability to handle conservation concepts improves with age, but no clear-cut

progression from one type of [illegible] conservation can be identified from the data. Lovell (1959) repeated six experiments from The Child's Conception of Space, using 150 children whose ages ranged from two years eleven months to five years eight months. Lovell reports that these young children did recognize basic geometric shapes displaying that Piaget's 'topological relationships' to be euclidian properties, as they are difficult for children at this age to express in precise language. He expressed suspicion that Piaget has been carried away with his interest in logic and in modern mathematics and has allowed these mathematical concerns to influence his psychology of cognitive development. Lovell does not cite any evidence to support these misgivings.

Peel (1959) reported findings from two experiments that strongly support Piaget's assertion that topological relationships are perceived before projective, and that euclidian and spatial concepts develop with age. The first experiment involving 60 children, ages three to eight, concerned children's ability to recognize shapes by touch alone. These findings confirm Piaget's assertion that in young children topological relationships are recognized with far greater ease than euclidian shapes. The latter experiment involving childrens' ability to cope with such shapes as closed figures, circles, squares, rhombuses, ellipses and crosses yielded results that Peel

[illegible]were strongly supportive of Piaget's stage sequence I, IIA, IIB, and III. Rivolre (1961) studied the development of spatial concepts using a sample of 144 children from ages four to fourteen. She administered a test designed to measure conservation of liquids in different geometrical containers. All items used in the test were checked by experts in geometry in order to be reliably certain that each item measured in the desired space, orientation and volume orientation, and to insure that there were easy and difficult items in each section. Rivolre's (1961) results did not completely support a specific stage orientation in conservation of volume. In particular Rivolre's sample of four year olds did not conceive of volume entirely as a function of conservation. Some of her fourteen year old subjects made incorrect responses to conservation items, while some four year old children correctly answered the conservation and volume items. However, this type of study was viewed as containing important factors other than the test results, revealing that the subjects ages were a significant factor in the performance of the test instrument. Three of the four replication studies just reviewed support Piaget's theory on the development of children's representational view of volume conservation, but only Rivolre's study cites discrepancies in the conservation of volume. Viewed collectively, these replication studies indicate that age

is a major factor in children s ability to correctly respond to tasks designed to test their conception of conservation.

There are clearly as many views as there are commentators. Hunt sees Piaget's theory as both hereditary and environmentalistic (Hunt, 1961). Almy (1966) describes four main factors which she thinks are incorporated in the system. These are maturation, experience, social transmission (association with other humans) and equilibration. Baldwin (1967) can ascertain neither material nor learning elements, nor a mixture of the two in Piaget's theories. He sees equilibration, the basis of transition or growth, as a third kind of development process altogether.

Equilibration is a sort of adaptive process based on two reciprocal processes of assimilation and accommodation. Assimilation is characterized as a taking in process. It is utilization of something from the environment. Psychologically, it is the ability of persons to handle new situations and new problems with already existing mental organizations. Accomodation, on the other hand, is the complexity complimentary process of assimilation. Whereas assimilation is organism favored, accommodation is environmental flavored in that the organism changes before it can assimilate phenomenon from the environment. Psychologically it is the alteration of the mental organization which makes new situations and problems

difficult to manage. When the processes are in balance we have an equilibrium and, hence, the process of seeking this balance is called equilibration. Equilibration should go well with any interaction theory of an organism experiencing in the environment.

In regard to the stages of intellectual development postulated by Piaget, these stages are really different times at which Piaget sees the structure of the individual's mental faculties being fundamentally different. That is to say, there seems to be three periods in the development of mental abilities of human beings, each that the organization of these abilities is different enough to be clearly distinguishable. The preoperational stage is a transitional one between the first two major operations--sensori-motor operations and concrete operations. These operations change through a process of equilibration and are built upon one another. Each new stage incorporates what came before and adds something new at the same time.

As one might suspect since the general intellectual abilities of the child develop through stages, specific abilities do also. Piaget & Inhelder's book, The Child's Conception of Space (1948), is an exposition of how the child psychologically develops the concept of geometric space. It is the study of certain problems of a general nature in regard to the development of spatial relationships

children deal particularly with the elaboration of projective and euclidian concepts out of more topological notions (Piaget, Inhelder, Szeminska, 1960).

There are numerous types of conservation such as conservation of area, space, length, number, time and size which have been investigated by Piaget and his colleagues. The conservation of volume is the type of conservation investigated in the present study. The basic technique used by Piaget and his colleagues to study conservation of volume was presented in Le Development Des Quantites Chez L'Enfant (1941). It involved presenting the subject with two balls of clay or plasticene identical in mass, weight and volume. This experiment, as well as others dealing with the conservation of volume, is discussed in this work. These experiments have been duplicated many times by many researchers, and criticisms of their origin and organization have been offered primarily by Flavell (1963). Although the various experiments more or less substantiate Piaget's stages and their sequences, many of the researchers are not absolutely convinced of the validity of his entire theory. In summary, these researchers have (1) speculated that Piaget has permitted his love of logic to interfere with his thinking, (2) he found various ages for his stages (3) he found that experience may have affected the mastery of the stages, and (4) speculated that the testing

situations itself, may have been a learning situation. Only one (Lovell, 1959) has found it necessary to attack Piaget's basic theory as such.

Observations made by two interpreters of Piaget, Baldwin (1967) and Flavell (1963), provide some good insights into Piaget's work as a whole. With respect to methodology, Baldwin noted that Piaget's experiments have been poorly controlled from the standpoint of experimental design and have been incompletely reported. Thus, despite the enormous amount of empirical data and the general confirmation of the findings, whether these experiments are repeated by others or not, one is still left with the fact that all the experiments must be repeated and confirmed by someone else before one can be confident about the child's range of response to the experimental situation, before one can know how many children are exceptions to the generalization, and before one can form an unbiased view of the empirical evidence. Baldwin modified his opinion little by adding that if we look at Piaget's work as "exploratory and hypothesis-generating", then the above criticisms lose much of their punch. (P. 31) Furthermore, Baldwin asserted that Piaget's postulations are not yet "rigorous theory of cognitive development". (P. 33) He also stated that Piaget became enamored with mathematics and inappropriately tried to apply mathematical constructs which did not fit the data.

Flavell (1963) categorized criticisms into the following three classes:

(a) Matters of theory and interpretation;

(b) Matters of experimental design and data analysis, and;

(c) Matters of upward and downward related data into theory and interpretation (Flavell, 1963, p. 102)

In the first category, Flavell complained about the difficulty involved in reading Piaget. Piaget's definitions overlap from book to book and mean different things under different circumstances, and Flavell contended that Piaget left holes in his reasoning from the empirical to the theoretical, and that he leaned toward over-theorizing. Flavell was generous in his second category when he made it clear that Piaget should not be criticized because he did not answer questions which his research did not intend to answer, such as the effect of the socio-economic backgrounds of the subjects. Also, Flavell said that it would be unreasonable to expect Piaget to explore in detail an area into which he had blazed a trail. On the other hand, Flavell insisted that much of the criticism of Piaget's experiments and theories are attributable to Piaget himself. In his opinion, Piaget failed to report that "important minimum" which even exploration should make clear. Hence, colleagues speak of validation rather than extension. According to Flavell, Piaget failed "to give a clear and full account of precisely

what he did in the experiment." (Flavell, 1963, p. 104) Not enough information was given to allow the reader to make his own judgment as to what is to be concluded. Apparently, Piaget not only lacked rigor in his sampling procedures, but even given the limitations of the "clinical method", the variations in his procedure were too great. Flavell complained that Piaget did not present even the most basic quantitative information. "As instances, he does not report the correlations between response level (stage) and age, nor even the essential characteristics of age distribution at the response level." (p. 62) Finally, the third type of complaint concerning the theoretical interrelation and interpretation of empirical evidence follows from the first two protests. Flavell felt that Piaget was guilty of over-interpreting the evidence, that he was "unparsimonious" in his interpretation and prone to multiplication and manipulation of the entities beyond necessity. (p. 64) He saw in Piaget's study a tendency to assert statements without the necessary justification, thereby appearing to force unwilling data into prearranged theoretical molds. Even though he noted these numerous defects, Flavell was favorably disposed toward Piaget's theory and found Piaget to be the foremost person in this field. As a matter of fact, Flavell emphasized the contribution of Piaget's work and defended it against what he considered to be unfair criticism.

Even with the criticisms and their defenses, the question

remains o[illegible] This change in thinking comes about What of the process through which the principal of conservation is acquired? Piaget's explanation is that an ocean of conservation is acquired when a child understands that every increase in height of liquid is compensated by a decrease in width. That is, an increase in one dimension is exactly compensated by a decrease in the other It is this compensation or equaling of differences which accounts for the transformation from non-conservation to conservation. A number of others have investigated this problem and offered alternative explanations.

Related Research to Conservation and Piagetian Theory

The concept of readiness has long been of interest to students of education. There can be little disagreement with the idea that children learn most effectively and efficiently when instruction is introduced at an appropriate time--neither too early nor too late but, rather when they are ready (Tyler, 1964)

An understanding of the student's cognitive development is a prerequisite to the complete understanding of the education process. A teacher can use the most advanced pedagogical techniques, employ the most highly regarded formal curriculum, be perfectly attuned to the desires of the students and still be quite unsuccessful in communi-

cating material. If the level of presentation is too advanced or too simple, relative to the cognitive development of the students, the class is likely to be a failure (Communications Research Machines, 1973. Educational Psychology: A Contemporary View.) Hilgard (1964) emphasized the importance of readiness. Appropriate instruction with suitable materials may be important factors in motivations for later intellectual activities. However, instruction can be introduced prematurely, it can be truly be delayed unduly. Soft sentimentality may be damaging to the personality so, too, may high expectations and requirements.

Scott (1962) pointed out the possible effects of introducing instruction too soon. He said that any attempt to reach a child at too early a period of development may result in his learning bad habits or in his learning not to learn, either of which may result in handicapping him in later life.

Agreement on the importance of readiness has been countered by disagreement about what produces readiness and about how to define readiness for particular curricular activities. Biehler (1971) explained the disagreement of theorists on how educational programs should be structured to allow for readiness. Those who hold the "natural" view of development feel that children should be exposed to a school curriculum which takes into account their level

of maturation. Therefore, these theorists believe that each child has developed to the point at which he is ready to benefit from each kind of school experience.

One of these "natural" theorists is Jean Piaget. His theory and research and the research of his followers tell something about readiness. We should not expect to work at the formal operations level when a child is still at the preoperations stage and has not developed the notions of conservation. Within a stage of development, difficult tasks should not be taught before simple ones (Hooper, 1968).

According to Hunt (1961),

> Piaget's description of the successive stages of intellectual development removes the necessity for some of the trial and error in determining an appropriate match between environmental circumstances and the nature of the central processes already developed for sustaining a positive interest in the environment and promoting accommodative growth of those central processes that underlie intelligence (p. 287).

Bruner (1960) seemingly accepts Piaget's position on intellectual development and it's significance for education. He says that the pre-operations child cannot grasp the idea of reversibility (a prerequisite to conservation), and that because of this deficiency the child cannot understand certain fundamentals that lie at the basis of mathematics and physics. Bruner rejects the idea of compensation as central to the acquisition of conservation and postulates, instead, that the identity or "sense of

sameness" is the basic factor in the acquisition of conservation. It is this hypothesis that a sense of identity is already present at an early age and that conservation is already present at an early age and that conservation is attained when the child is able to free himself from the dependence on perception of a single feature and use his previously established sense of identity as a basis of judgment, that was investigated in one of the conservation experiments carried out by Bruner with children from ages four to seven (Bruner, 1966). During the course of the experiment each subject watched while water was poured from one beaker to another; he was then asked whether there was the same amount of water as before and to give his reason for the answer. The reasons given by the children were categorized as follows:

(1). Perceptual, reasons relating to size, shape, and appearance.

(2). Identity, reasons mentioning the identity of sameness of the water.

(3). Conflict, reasons implying conflict between how the things looked and how they really are.

It was found that the reasons given by four and five year olds were 48% perceptual, 46% identity, and 6% conflict. While reasons given by the six and seven year olds were 16% perceptual, 57% identity, and 27% conflict. As the

children grew older more of them gave identity and conflict responses and fewer gave perceptual responses, with more than half of the six and seven year olds giving identity as the reason for conservation. It was noted that all the children who gave perceptual reasons gave non-conservation responses

Piaget (1962) has characterized the reasons which children give when asked to explain their basis of conservation as: (a) identity, (b) reversability, or (c) compensation. He postulates that all three have some relationship to the acquisition of conservation, but that compensation is really the crucial factor

Bruner (1966) on the other hand believes that his work has shown that identity is the primary factor and that the child appeals to reversibility or compensation to justify what he already knows to be true, that the amount of water is the same in spite of the appearance to the contrary. Yet Bruner maintains "that any subject can be taught effectively in some intellectually honest form to any child at any stage of development" (pp. 33)

Larsen and Flavell (Lovell, 1959) using difference conservation tasks with kindergarten and second grade children obtained results which failed to support Piaget's hypothesis "that compensation is a prerequisite for conservation". Cathcart (Baldwin, 1967) found that the second and third grade subjects of his study were clear in

their preference for identity responses as to the eight items of conservation tests. Hamell (Lunzer, 1960) also obtained results which support Bruner's hypotheses. The evidence from Bruner's work and other studies is that children from age four to third grade give more identity responses than reversability or compensation responses.

A totally different point of view, proposed by Gagne (1970), describes learning readiness as being comprised of three factors: attentional sets, motivations and developmental status. While it might appear that he is in agreement with Piaget by his use of the term 'developmental status", such is not the case. Gagne views intellectual development as being "primarily attributable to the cumulative effects of learning relatively specific intellectual skills' (p. 200). Readiness for Gagne then, depends not on maturation, or even on an interaction between maturation factors and environmental factors, but solely upon the repertoire of skills possessed by the student which have been previously learned and which are relevent to the new learning task to be undertaken (Gagne, 1962).

While Piaget has not encouraged the acceleration of cognitive development, many American researchers have attempted to speed up the movement of children through Piaget's stages. Almy et al (1966) points out some of the possible disadvantages of such efforts:

We detect in some of the reports of experimentation and in some of the discussions of the possibilities for advancing the child's understanding by matching or pacing his intellectual development, a degree of impatience with the playful, imaginative, highly personalized thoughts of the young child.

We infer that the sooner childish thoughts are put away, the more surely and the more insightfully the person enters into the intellectual kingdom set up for him by the great thinkers of the various disciplines.

> "... Viewed from another direction, the playful and, to the adult, unsystematized thought, of the young child may serve to integrate the patterns of action ... that make up the intellectual repertoire of the infant or the toddler ... there is no guarantee that instruction in specific concepts will necessarily hasten the transition from one level of thinking to the next. But even if evidence occurs that it does, the question of whether such acceleration, from a longterm view, enhances or stultifys the individual's abilities for speculative, imaginative, even creative thinking still needs investigation." (Almy, et al, 1966, pp. 129-130)

Some attempts at the acceleration of conservation have been successful and some have not. Smedslund (1961) found it was possible to accelerate the development of the concept by teaching concepts related to conservation to an experimental group. However, the children in the control group, who learned conservation in the "natural way", were able to give better explanations in a related post-test at a later date.

In one study (Sigel, Roeper & Hooper, 1966), children were trained in multiple classification, multiple relationality and reversibility, all operations necessary for adequate conservation performance. Conservation of quantity was acquired after the training period. Beilin & Franklin (1962) conducted an experiment in which first and third graders were taught to apply the conservation principle to area, while the first grader made no observable progress the implication was that age per se is a critical factor.

Beilin (1962) used verbal rule instruction in conservation training and was successful in inducing conservation, but he was unable to obtain generalizations to other conservation tasks. Kingsley & Hall (1967) concentrated on skills directly related to the conservation of length and effectively taught conservation on specific tasks. But, they, too, failed to obtain generalizations.

Many attempts at conservation modification or acceleration have produced negative results. Wohlwill (1960) and Wohlwill & Lowe (1962) tried to teach children to conserve number and were unable to do so. Gruen (1965) unsuccessfully used training procedures in an attempt to induce conservation of number skills in kindergarten children.

There is, then, disagreement about how to define readiness and how to measure it. In looking at the attainment of the principle of conservation, it has been

shows that there is considerable variance in the age at which children master this principle (Peters, 1968; Wallach, 1961). Why the variance in age if Piaget's theory of mental maturation is valid? If instruction has been carefully planned, why has the child not mastered this principle? Bruner maintains that any subject can be taught effectively to any child at any stage of development. Gagne would say the child does not possess the skills required to master the principle.

It appears that one kind of useful research is the examination of a child's acquisition of the principle of conservation as it relates to the use of different methods of instruction and how this instruction relates to particular aptitudes of the child. It might be that the child has not been exposed to the proper instruction that allows assimilation of conservation as a useful principle. The aptitudes the child possesses might inhibit or enhance acquisition through instruction. The development of conservation skills is a necessary prerequisite, according to Piaget, to the understanding of mathematical and science concepts. The acquisition of conservation, then, would be an important part of readiness for each.

Piaget (1952) said that it was necessary for children to grasp the principle of conservation of quantity before they could develop the concept of number. This notion is strongly stated as follows:

"Obviously conservation, which is a necessary condition of all reasoning, by no means exhausts the representation of reality or the dynamism of the intellectual processes[illegible] Our contention is merely that conservation is a necessary condition for all rational activity or to explain the nature of reality. . .this being so, arithmetical thought is no exception to the rule. . . From the psychological point of view, the need, for conservation appears then to be a kind of functional a priori of thought ' (Piaget, 1952, P 3)

Perhaps some of the negative results of earlier conservation experiments might be accounted for in the following ways:

1. The responses relied on verbal abilities of the child. Few if any of the experiments attempted to correlate verbal ability versus response

2. The number of required responses was very small, increasing the element of change which increased the error of these statistical treatments.

3. Most designs assumed each child entered the experiment with no serious aptitude advantage or disadvantage.

4. Treatment groups were small and interaction analysis was difficult

Definition of Variables for Aptitude x Treatment Interaction Studies

Theory of Aptitude x Treatment Interaction Research

In the development of effective instructional methods one problem has been paramount in reaching a real measure of success How do we determine the most effective method for training large numbers of students possessing dissimilar

patterns of abilities? One of the strategies usually employed has been to seek 'the one best method of instruction". Fuller (1969) proposed that individualizing instruction for students was an important feature of effective instruction. Hereford (1971) and Merrill (1968) viewed the varying of educational objectives, pacing and sequencing according to student characteristics as a possible mechanism for individualizing instruction.

However, learners differ and the search for the one generally superior method should be supplemented by a search for multiple ways in which instruction can be varied so as to fit the characteristics of learners. (Cronbach & Snow, 1969, reviewed by Koran, M. L., 1972)

As Cronbach (1957) has enounced,

> "The treatments are characterized by many dimensions; so are persons. The two sets of dimensions together determine a payoff surface. Ultimately we should design treatments not to fit the average person, but to fit groups of students with particular aptitude patterns which correspond to modifiable aspects of the treatment." (pp. 680, 681)

The thrust of this statement is that educators should not ignore interactions between learners' aptitudes and various instructional treatments, but adapt instructional treatments to learners' aptitudes. Cronbach (1965) has developed a theoretical framework to deal with the immense task of different aptitudes and differing instructional treatments. He has labeled these studies Aptitude Treatment Interaction studies, or more commonly called, ATI studies.

The concept of Aptitude Treatment Interaction is not a novel idea in the scientific world, environmentalists have been using this concept for some time. The concept of a single rank ordering applied either to organisms or environments ignores the fundamental principle that it is the interaction between the characteristics of the organism and the demands of the environment that determines survival or elimination. Similarly, the current search of ATI is based on the premise that there is no one best educational environment suited to some general, average (individual), but that different individuals thrive in different educational environments suited to their own characteristics and needs. (Koran, M.L., 1973)

An interaction between aptitude and treatment is present when one instructional treatment is significantly better for one type of learner, while an alternative treatment is significantly better for a different type of learner. (Koran, M.L., 1973) More specifically, for instructional treatments to exhibit ATI, there must be different instructional methods. The instructional methods must teach to the same objective or criterion, and there must exist one or more aptitude measure for which regression of criterion scores on the aptitude are generally nonparallel.

Basically, there are two types of Aptitude Treatment Interactions which might result they may be either

[illegible] disordinal interaction [illegible] Snow 1969)
A disordinal interaction is one in which the regression slopes intersect within the range of the aptitudes being considered (Figure 1)

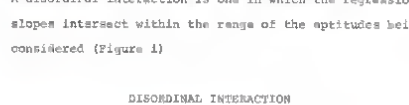


FIGURE 1

Such findings imply, in general, that different assignment of subjects on opposite sides of the interaction to alternative treatments is appropriate for maximizing learning outcomes (Kerlan, F.N., 1973) An ordinal interaction is present when the regression functions have different slopes, but one is superior to the other through the range of aptitudes being considered (Figure 2).

ORDINAL INTERACTION

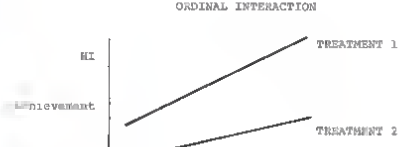


FIGURE 2

The general objective of ATI research is to match instructional methods or materials to selected learner characteristics. Therefore, unless one treatment is obviously best for all, some differentiations should be performed in such a way as to maximize their interactions with aptitude variables. A considerable number of studies in which aptitude treatment interactions have been deliberately sought (Cronbach & Snow, 1969; Berliner & Cahen, 1973) provides initial evidence to suggest that subjects may learn more easily from one method than the other. In addition, this best method differs from subject to subject and that such a difference between treatments is related to learner characteristics.

For the purpose of Aptitude x Treatment Interaction research, aptitude has been defined as <u>any</u> characteristic

of the individual which functions selectively with respect to learning; that is, which facilitates or interferes with his learning from some designated instructional method. (Cronbach & Snow, 1969) This formal definition allows such variables as task specific knowledge and skills, cognitive styles, personality characteristics and heuristic strategies to be considered as well as the more traditional cognitive ability variables.

Therefore, one problem in the study of Aptitude x Treatment Interaction is the inordinately large number of learner characteristics which might be considered in adapting instruction to individual differences. Moreover, few of these differences have been shown to be correlated with specific learning outcomes under specific instructional methods in the particular population specified. In addition, there has been a comparative lack of precision in describing the task or treatment variables. For this reason treatment has been broadly defined for the purposes of ATI research to include variations in structure, pacing, style or modality of instruction, although eventually this definition should be expanded to include noninstructional situations as well. (Cronbach & Snow, 1969)

It is common in ATI research to find two treatments one of which relies more heavily on general ability than the others. Some research reports instances in which a treatment will help those of low ability while actually

[illegible]ch ability students. (Solomon & Suppes, 1972; Koran, Snow & McDonald, 1971). M. L. Koran (1971) in an experiment designed to test the differential effectiveness of a video model versus a written model in the acquisition of a teaching skill, found that the fixed-paced, attention-restricting video demonstration was more effective for the low ability trainees, while the self-paced, nonrestrictive written instruction was more effective for high ability trainees. Even with this research there has been little real progress to date in identifying heuristics for developing treatments that actually capitalize on aptitudes other than general abilities. The acquisition and subsequent retention of information from instructional sequences can be analyzed as a function of numerous variables including learner predispositions and variations within the treatment materials. While these variables can be factor analyzed in order to relate performance to a number of reference tests, such an analysis must be guided by theories of human learning and performance in order to facilitate the interpretation of results. Melton's (1967) multiprocess model of learning is considered to be a suitable framework for investigating instructional differences and mediational requirements between specific instructional variables.

MULTIPROCESS [illegible]

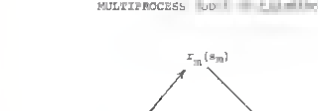


FIGURE 3

This model presents three major components that help interpret certain instructional phenomena. The first of these is a stimulus differentiation component [$s_1 \longrightarrow r_1$] in which the subject receives the physical stimulus [s_1] and selects and encodes certain stimuli as stimulus cues [$r_1(s_1)$]. The potential stimulus is considered to be the entire stimulus situation of the learning environment. The encoded stimulus becomes the effective or functional stimulus in S-R association, and reflects learning set, identification and categorization factors, as well as the physical stimulus. Instructional materials attempt to indicate the relevant aspect of the physical stimulus through the selection of reading passages, questions, diagrams, summaries, and other instructional components.

From this, the student selects particular aspects which become the stimulus cues. Directions, instructions, elicitations, or models that direct this selection are called prompts. The encoded response $[r_i\{s_i\}]$ becomes the effective or functional stimulus for subsequent psychological learning activities.

The response integration component $[R_aR_bR_c]$ is the output response and includes certain learning behaviors such as naming, classifying, or chaining as well as the specific content presented in the instructional materials. Such behavior may be a previously learned unit $[R_a]$, or a new combination of units $[R_aR_bR_c]$, or even a chain of responses from one stimulus situation $[R_a+R_b+R_c]$.

The "hookup" is the connection $[r_1\{s_i\}\longrightarrow R_aR_bR_c]$ between the functional stimulus $[r_i\{s_i\}]$, and the acquired response $[R_aR_bR_c]$. The component $[r_m(s_m)]$ presents an alternative mediational route for the connection of internal representation of the physical stimulus and the acquired response. The mediational route is especially important in examining ways learners can use prior learning with new but recognizably similar stimuli. The associational and mediational routes correspond to the internal processes of the task being analyzed.

Differences and similarities in task and aptitude variables involved in learning from different modes of information within instructional material may be represented in terms of this paradigm.

Aptitude x Treatment Interactions
Related Research

The preschool domain is an area where few ATI researchers have cared to venture. Since most aptitude or achievement measures require verbal ability to measure performance, the lack of valid and reliable instruments have deterred most. However, there have been those who have created instruments to explore unknown which encompasses the area of early childhood.

Many view IQ scores and verbal ability as strong aptitudes which have much interaction with many tasks. The Wechsler Preschool and Primary Scale of Intelligence (WPPSI), Stanford-Binet Intelligence Scale (form L-M), the Peabody Picture Vocabulary Test (form A) and the Pictorial Test of Intelligence (French, 1964) are but a few of the instruments to measure IQ and verbal ability at the early childhood level. Other measures which have sought to investigate the preschool age child are the Matching Familiar Figures Test (MMF, Kagan), Haptic Visual Matching Test (HVM), Color-Form Test and many more which seek to examine specific aptitudes or levels of achievement.

Impulsivity - Reflectivity as an ATI Measure: Related Research

The tendency to pause before answering an problem-solving tasks has been the focus of a series of studies

under the general heading of reflective-impulsive (Kagan, 1965a, 1965b, Kagan & Kagan, 1970). The impulsive child offers his answer more quickly and makes more errors than his reflective counterpart on a match-to-sample task called Matching Familiar Figures (MFF) (Kagan, Rosman, Day, 1964). In this task, the subject is required to select from among several alternatives the one that exactly matches a standard. Previous investigations have established the presence of stable individual differences in this cognitive disposition and have extended the network of it's correlates into the other cognitive spheres, including inductive reasoning, reading ability and serial learning. More specifically, with verbal ability controlled, the reflective as compared with the impulsive child, has been shown to display fewer errors on tasks of inductive reasoning which called for the completion of sequence according to a logical principle (Kagan, Pearson & Welch, 1966); made fewer errors of recognition in a test where one word presented orally had to be recognized among five written words (Kagan, 1965c) and made fewer errors of commission in recalling words in a serial learning task. (Kagan, 1966).

Adams (1972) investigated strategy differences between reflective and impulsive children who were examined in a study of 50 six year old and 52 eight year old white children using a three choice probability learning task. Adams found that there were significant differences in performance between impulsive and reflective children

In addition, he found a significant interaction between age and conceptual tempo.

Judith Katz (1971) conducted a study to determine whether the differential development of conceptual tempo could predict preferences in color-form sorting among young children. The subjects were 67 children ranging in age from 44 to 65 months selected with various socio-economic backgrounds. The color-form sorting task was comprised of three stimulus series which varied with regard to the relative of color and form. Results showed that reflective children made more form responses to all three stimulus series than impulsive children. The study did indicate an interaction between impulsivity and sex.

Goodman (1969) investigated the relationship between reflection-impulsivity as assessed by Kagan's Matching Familiar Figures Test, and verbal control of motor behavior of kindergarten children. The results indicated a relationship between the dimensions of conceptual tempo and the ability of control motor behavior verbally. The study demonstrated that impulsive children's self-verbalizations are less effective in controlling their motor behavior than those of reflective children.

Impulsivity and reflectivity, as well as verbal ability, are aptitudes which seem to be important in a child's conquest of conservation theory.

Aptitnde x Treatment Interaction:
Conservation Research

An analysis of Aptitude Treatment Interaction could aid in explaining why a particular instructional design does not account for differences in conservation performances among different types of students. Many researchers have asked the question, "What are the psychological processes involved in the transition between Piaget's stages of development?" Piaget's explanations, based on adaptive cognitive restructuring, seem highly inadequate to account for the differences in performance (Peters, 1968) Studies dealing with verbal and nonverbal criteria have shown significant aptitude interactions which could hope to account for these differences in performance. (Braine, 1959, 1962; Medhler, Neve, 1967) Piaget uses evidence of conservation acquisition as an indicator of sequential cognitive progress through several stages which terminate in successive levels of equilibrium. Thus, mastery of different types of conservation occurs in an invariant sequence which represents or is evidence for different stages of intellectual structure through which all children must pass. These studies produced considerable variations in the use of materials in assessing conservation, while at the same time additional training following Piaget's equilibration generally has not been successful in accounting for individual difference. (Beilin, 1965; Wohlwill & Lowe, 1962)

Wohlwill & Lowe (1962) attempted to relate verbal ability and mastering of the principle of conservation. The results showed no meaningful correlation. An explanation for their results might be found in their treatments, they designed the treatments using Piaget's equilibration model.

Although training may serve to speed up acquisition somewhat, most supporters of Piaget would argue that it is impossible to alter the sequence or bring about too rapid a change. The literature is replete with failures to train young children to master different types of conservation (Gruen, 1965; Wohlwill & Lowe, 1962) These failures have of course been interpreted as substantiation for the Piaget position After reviewing many of these attempts to train conservation, Flavell (1963) indicates, "Almost all the training methods reported impress one as sound and reasonable and well suited to the educative job at hand. And yet, most of them have had remarkably little success in producing cognitive change". (p. 377)

When successful training procedures are found, they are assumed to effect the cognitive structure Such terms as "cognitive conflict" again emphasize internal rather than environmental variables. It is maintained these procedures are only successful with children who are in possession of the proper cognitive structure but have not yet reached equilibration

In one study (Sigel, Roeper & Hooper, 1966) seven year old children were trained by instructors in multiple

classification, multiple relations, reversibility, all operations necessary for adequate conservation performance. Conservation of quantity was acquired after the training period.

Bailan & Franklin (1962) conducted an experiment in which first and third graders were taught to apply conservation principles to area. The third graders improved significantly in the handling of area while the first graders made no observable progress. The implication was that age, per se, was the critical factor.

Beilin (1962) used verbal rule instruction in conservation training and was successful in inducing conservation with eight year old children. He was unable to obtain generalizations to conservation tasks.

Kingsley & Hall (1967) concentrated on skills directly related to conservation of length and effectively taught conservation on specific tasks, but they, too, failed to obtain generalizations.

In each of the four mentioned cases, individual differences of students were not examined. Perhaps an Aptitude x Treatment Interaction analysis could have added strength to these studies.

Barbara Rothenberg (1967) reported results in conservation tasks involving 210 lower and middle class preschool and kindergarten age children. The results showed important differences in the number of conservers identified, depending on the conservation question or the questions asked and the

number of transfer formations [illegible] It was seen that lower class children were more [illegible] accurately assessed in terms of conservation status than middle class children. The results also suggested that further studies should be devoted to the realistic use of student justifications. Overall, only six percent of the students were actually found to be conservers. Further, there were no consistent differences in the effects of materials when the sample was divided by age and sex. There was also no significant difference in the distribution of explanations given to justify the responses to the conservation questions. These results indicated that situations of provoked correspondence, as measured by uniquely matched pairs, did not facilitate conservation to a greater extent than those of spontaneous correspondence as measured by entirely homogeneous objects.

Peters (1970) investigated the phenomenon of acquiring conservation. At first, he sought the role played by language comprehension and analytical style in conserving performance of kindergarten children. Secondly, he used an Aptitude Treatment Interaction model for viewing the relationship of the same variable to alternate forms of instruction. The forms of instruction were non-cue discovery, perceptual cue guided, verbal rule instruction and no training control.

Others previous to Peters had looked at language comprehension as a possible variable which could account for individual differences, but each failed to do an Aptitude

[illegible] differences into clear view. Such is the example in the Griffin, Shantz & Sigel study (1967) which concerned itself with the ability of preschool children to use relational terms of more, same and less when comparing number, length and weight of objects as they related to conservation tasks. In this study the students were given the Stanford-Binet IQ test. Even though verbal scores were received for these children, they were merely mentioned in their report, and no interaction analysis was performed with these students.

Likewise, in the Rothenberg study (1967), a Peabody Picture-Vocabulary test was given to each of the students to measure verbal intelligence through measuring comprehension of spoken words. Even though raw scores and mean scores were reported in the study, and there were statements recording no significant sex differences for any of the age groups, Rothenberg mentioned the verbal results. The report did show significant differences of IQ between four and five year old students. Again, no interaction analysis was performed to analyze individual differences among students.

In a later study, Kingsley & Hall (1967) used Gagne's hierarchy of subtasks in training of conservation in young children. The children in the experimental group were pretested on knowledge hypothesized to be necessary in mastery of weight and length conservation, along with actual conservation tasks in length and weight. They were trained

on weight and length conservation only and posttested twice to determine (a) the effects of weight and length conservation acquisition, and (b) the effects of weight and length conservation on substance conservation. The most crucial question, which was the effect of their training on individual differences, must still remain unanswered as the author dealt only with defining behaviors that were needed for successful mastery of conservation.

Earlier, Peters (1970) analyzed individual differences among students based on cognitive style which could relate to Gagne's learning theory through the use of hierarchy subtasks.

Peters (1968), using language comprehension and analytic cognitive style in the conserving performance of kindergarten children, applied Aptitude Treatment Interaction analysis in preparing alternative models of instruction:

> The results of the study have indicated that acceleration of the learning of conservation of numerical correspondence can be brought about through direct training based upon the notion of reversibility. The ATI analysis suggested that subjects who entered the high analytic scores and low verbal scores should be assigned to the verbal treatment, and the high language, low analytic subjects should be assigned to the perceptual treatment to maximize their performance. (p. 47)

Strickland (1976) conducted a study which focused it's attention on diagnosing the presence of conservation aptitudes in subjects determined to be in the Piagetian preoperational period, and secondly, examined conserving performance of preschool children (Ages: 2-75 - 5-8 years)

using an Aptitude x Treatment Interaction ATI model in which the differential effects of cognitive style, impulsivity-reflectivity and verbal ability were examined in relationship to a Didactic method of instruction versus a control group.

In this study 120 preschool children were administered the verbal section of the Wechsler Preschool and Primary Scale of Intelligence (WPPSI) test and using a sorting task (Peters, 1968), determined the cognitive style of the preschool children. Impulsivity-reflectivity was measured using the Matching Familiar Figures test (MFF) developed by Kagan (1966).

The results indicated that conservation of number is related to chronological age of children, in that older children did perform significantly better than their younger counterparts. In addition, the learning of number conservation seemed to have more stability over time with older children. The MFF test revealed that reflective students did significantly better on the conservation measure than the impulsive students, $F = 82.60$ ($P < .01$). However, the impulsive students who were in the Didactic treatment group performed better than the impulsive students that were in the control groups $F = 8.26$ ($P < .05$). The Didactic treatment group performed significantly better on the conservation of number task than the control groups $F = 103.79$ ($P < .01$). The significant difference between the treatment and control groups suggests that conservation of number can be taught; moreover, that it does not diminish

as a function of time. The stability of this [illegible] is most important as many Piagetian researchers have [illegible] that Piagetian tasks are acquired only through maturation.

Another significant feature of this study was the development of the conservation of number instrument. In the past, the conservation of number has been tested by one or two examples administered verbally and inconsistently to students. This measure provides a reliable (.85) method of obtaining the child's conservation of number level. If conservation of number and of other areas are significant in the learning processes, then they should be accurately assessed in teaching methods developed to gain proficiency. After careful examination of the results of this study cited above, further research was suggested investigating methods of instruction which might further take advantage of these student aptitudes.

Independent and Dependent Variables

The purpose of this study is to investigate the presence of conservation aptitudes in preschool children and the effect to which training might alter this aptitude. Thus, a dependent variable in this study will be performance on the posttest conservation measure. The treatments should serve as independent variables in this study.

When aptitudes are included in addition to the instructional variables built into the instructional treatment, then differential performance of the treatment group can be compared by regressing the aptitude measure on the posttest

performance. In this manner, a relationship can be established between learner characteristics and instructional variables that influence their acquisition. Hence, impulsivity-reflectivity is to be considered an independent variable (a blocking variable in the analysis of covariance) while posttest performance will remain a dependent variable. Pretest performance and full scale IQ will be treated as coveriances and used as covariates in this study

Statement of Hypotheses

Based upon the previously reviewed research and theory, the following hypotheses are to be tested.

1. There will be a significant positive influence on conservation performance for subjects who receive the Verbal Didactic method of instruction when compared with the performance of the control group.

2. There will be a significant positive influence on conservation performance for subjects who receive the Alternative Example method of instruction when compared with the performance of the control group.

3. There will be a significant positive influence on conservation performance for subjects who were typed impulsive or reflective

4. There will be a significant interaction between the type (impulsive-reflective) of student and the instructional treatment.

5. There will be a differential relationship between conservation performance and aptitudes of subjects relative to the treatment received

CHAPTER II

EXPERIMENTAL DESIGN

The Design

A pretest, posttest, control group design as described in Table 1 was executed with two experimental groups and one control group. The students were randomly assigned to the three groups. Group one received two aptitude tests (MFF, WPPSI), the pretest (conservation of number), Verbal Didactic instruction and the posttest (conservation of number). Group two received two aptitude tests (MFF, WPPSI), the pretest (conservation of number), Alternative Example instruction and the posttest (conservation of number). Group three received the two aptitude tests (MFF, WPPSI), the pretest (conservation of number), a placebo treatment and the posttest (conservation of number). This gives a modified solomon four group matrix which is illustrated in Table 2.

This design provides information about the entering behavior of the students, and in a pilot study Strickland (1976) found that the instruments control for pretest sensitivity. In addition, this design controls for maturation, testing, regression, selection, mortality, and interaction of selection and maturation. (Campbell, Stanley, 1966). All students were randomly selected and assigned to

TABLE 1
EXPERIMENTAL DESIGN

R_1	Pretest (O_1)	Verbal Didactic (x_v)	Posttest (O_2)
R_2	Pretest (O_3)	Alternative Example (x_a)	Posttest (O_4)
R_3	Pretest (O_5)		Posttest (O_6)

TABLE 2
EXPERIMENTAL DESIGN

Aptitude Test		Pretest	Treatment	
MMF, WPPSI	R	O_1	x_v	O_2
MMF, WPPSI	R	O_3	x_a	O_4
MMF, WPPSI	R	O_5		O_6

treatment groups. Each student was given a code number for test identification to protect his or her identity. All students selected were given two tests which are described below.

Aptitude Measures

Verbal Ability (VA) - WPPSI Vocabulary and Information Subtests

The Vocabulary and Information scales of the Wechsler Preschool and Primary Scale of Intelligence (WPPSI) was administered and scored in the usual fashion. Birth dates were obtained from school records and scaled scores were computed. The predictive validity, as assessed by later performance or achievement tests, appeared to be better for the WPPSI than for the Stanford-Binet, Peabody, Bender-Gestalt or Draw-A-Person (Pokorski, Frede & Gantney). Reliability estimates ranged from .87 to .94 depending on the subtest and age group, the verbal subtest being the most reliable of the age range, .89 to .96.

Matching Familiar Figures Test (MFF)

This is a standard instrument devised by Kagan et al. (1964) to assess cognitive tempos in children. The version of the test which was administered in this study was the pre-school version designed for children ages 2.7 to 6.9 (Kagan, 1966). The MFF measures a child's tendency to have a reflective or impulsive cognitive

style. On this task a child looks at one standard stimulus line drawing and must point out an exact match from among six alternatives. He is scored for response latency (time from exposure to first response) and number of errors on each of twelve trials. A child who is below the group median on response time and above the group median on errors is considered impulsive. A child who is above the median on response time and below the median on errors is considered reflective. Reliability, both test-retest and internal consistency, have been reported by researchers using the MFF with elementary and pre-school children (Kagan, 1965, 1966; Denney, 1973). The range for test-retest reliability was reported as being .62 to .73 depending on the age of the child (Kagan, 1966; Denney, 1973). The range of coefficient alphas were reported to range from .67 to .78.

Subjects were tested using the aptitude measures prior to their participation in the experimental procedures. As shown in Table 3, tests required 98 minutes of total test time, and for this reason the WPPSI was administered the first day and the Matching Familiar Figures Test the second day. The Wechsler Preschool and Primary Scale of Intelligence Test is in kit form and requires that the test be administered one student at a time. Likewise, the Matching Familiar Figures Test is in booklet form

and requires that the test be administered one student at a time. Since the students had been previously randomly assigned to one of three treatment groups, any regressive effects caused by testing and time delay were randomly distributed to all treatments.

The Wechsler Preschool and Primary Scale of Intelligence was hand scored by the examiner and a raw score for each part was obtained. Using tables furnished by the WPPSI test scaled score equivalents of raw scores were obtained for each child. A scaled score for the verbal section and the performance section were obtained. Each of the tables are based on the age of the subject and are divided into quarter year intervals. Having obtained the scaled scores of the verbal section and the performance section, the IQ equivalent of the sums of scaled scores was computed using the value found in Table 22 of the WPPSI manual. Using Table 23, the IQ equivalents of sums of scaled scores for full scale IQ were obtained. Even though all the students could not be tested at the same time, they were all tested in a like manner using the WPPSI kit of materials and examiners manual.

TABLE 3
APTITUDE MEASURES

TEST	TIME	NUMBER OF PARTS GIVEN
Wechsler Preschool and Primary Scale of Intelligence	75 minutes	10
Verbal Section of WPPSI	(35 minutes)	5
Performance Section of WPPSI	(35 minutes)	5
Matching Familiar Test (MFF)	15 minutes	1
Actual Aptitude Test Time	90 minutes	
Administration, practice sets	8 minutes	
Total Aptitude Test Time	98 minutes	

Kagan's twelve-item Matching Familiar [illegible] (MFF) was then administered (Kagan, et al., 1964). The examiner said, "I am going to show you a picture of something you know and then some pictures that look like it. You will have to point to the picture on the bottom page (he/she points) that is just like the one on this top page (he/she points). Let's do some for practice." The students were shown practice items and helped to find the correct answer. Then the students were told, "Now we are going to do some that are a little bit harder. You will see a picture on top and six pictures on the bottom. Find the one that is just like the one on top and point to it."

The examiner recorded latency time (the time required to make the first choice) to the nearest tenth of a second, total number of errors for each item were recorded and the order in which the errors were made. If the child was correct, the examiner praised him. If wrong, the examiner said, "No, that is not the right one. Find the one that is just like this one (he/she points)." The examiner continued to count responses (not times) until the child made a maximum of six errors or a correct choice. If incorrect after six choices the child was shown the correct answer.

Pretest - Posttest Measures

The pretest and posttest measure was a measure of conservation of number. The validity of the measure was determined by extracting the test items from the text The Child's Conception of Number (Piaget, 1952) and additional work performed by Educational Testing Service (Rothenberg, 1969). These conservation tasks were developed by modifying the procedures and materials of previously reported measures of number conservation (Flavell, 1963; Piaget, 1952; Rothenberg, 1969). An attempt was made in the conservation task development to provide an unambiguous a situation for the child as possible while preserving the essential elements of the conservation of number paradigm. The first modification was the introduction of an 18 x 24 inch board which was fitted over a table top and used during the entire administration of the task. The board was painted half yellow and half blue with the two halves separated along the long axis by a narrow black line so that an array placed on one side would be clearly distinguished from one on the other. The board was also used to minimize feelings of competition on the part of some of the children by referring to an array as "the one on the blue side" or "yellow side", rather than 'the one on your side" or "my side"

The second modification was the assessment of and instruction in concepts basic to an adequate performance on the task. These concepts were: "yellow" and "blue", as pertaining to the board, "bunch", which was used throughout the task as the equivalent of "row" because it seemed more understandable to the children, and "numerical equivalence", meaning that the students had to make a bunch just like the examiner's and know that the two arrays were equal in number.

The third change was the use of warm-up item in order to give the students a chance to become familiar with the question format to be used in the items as well as to provide a base line for estimating how well the students understood the language of the questions apart from the difficulty of the actual test transformations. Twelve types of transformations were selected from the many possibilities. These included various linear examples but no nonlinear or spatial arrangements because most previous work in the field had been done with only linear arrangements. The general categories of the conservation of number transformations are: equal subtraction, lateral displacement, collapsing, regrouping, equal addition and conservation of inequality as described in Figure 3. The complete 24 item test arrangement is reported in Appendix B. The top-bottom arrangement of the twelve items were reversed, yielding 24 items in the conservation test. This

CONSERVATION OF NUMBER TRANSFORMATIONS

Type 1	Lateral Displacement	S: 0 0 0 0 0	
		E: 0 0 0 0 0	
	(E-Row manipulated)		
Type 2	Collapsing	S: 0 0 0 0 0	
		E: 00000	
	(E-Row manipulated)		
Type 3	Regrouping	S 0 0 0 0 0	
		E: 00 000	
	(E-Row manipulated)		
Type 4	Equal Addition and arrow indicates added elements	S: 0 0 0 0	
		E: 0 0 0 0	
	(Both Rows manipulated)		
Type 5	Equal Subtraction and arrow indicates subtracted elements	S: 0 0 0 0	
		E: 0 0 0 0	
	(Both Rows manipulated)		
Type 6	Unequal Addition and arrow indicates added elements	S: 00000	
		E: 0 0 0 0	
	(Both Rows manipulated)		

FIGURE 4

[illegible] included to reduce the error which might be [illegible] by the student making selections on the same side of the board but without understanding conservation of number. In a pilot study (Strickland, 1976) (See Appendix A) on conservation of number using this instrument, the reliability was determined using the split-half method and found to be .86 Internal consistency reliability coefficient was computed for the conservation test during the pilot study and found to be .71 The coefficient alpha was computed for the present study and found to be .89 In addition, an item analysis was performed on the conservation test using a point-biserial correlational technique A point-biserial correlational technique was selected to evaluate their reliability. This technique is considered to be a suitable means to estimate an item's potential to discriminate between subjects who score in the top half and those in the bottom half of the group being tested. A point-biserial correlation of 0.250 ($P < .01$) was considered minimum for acceptable reliability for individual criterion items. Point-biserial correlations for the conservation test questions are reported in Table 4 Reliabilities of all questions were found to be acceptable.

The difficulties for the 24 questions were also calculated and are also reported in Table 4 Difficulty here is defined to be the percent of the subjects failing

TABLE 4
RELIABILITY AND DIFFICULTY OF
POSTTEST QUESTIONS

Question	Difficulty	Reliability*
1	525	.522
2	125	.510
3	908	.387
4	880	.298
5	200	.675
6	225	.563
7	.484	.511
8	832	.363
9	.929	.297
10	.592	.521
11	.275	.622
12	.500	.602
13	.325	.339
14	.400	.432
15	.250	.615
16	.300	.350
17	.600	.610
18	.580	.355
19	.625	.357
20	.473	.521
21	.880	.298
22	.641	.434
23	.815	.263
24	.225	.304

* ($F < .01 = .250$, df = 88)

to answer the questions correctly. The higher [illegible] the more difficult the item. The mean difficulty was 0.610 while the range of difficulties varied from 0.125 to 0.929.

Treatment Procedures

Subjects

The subjects were ninety preschool children attending three different private non-profit schools in Gainesville, Florida. The mean age of the students was 4.60 with a range of 3.0 to 5.8 years. The distribution of the subjects by sex, age and treatment group are reported in Table 5. The subjects were randomly assigned to treatment groups prior to any testing and were randomly selected from a group of 260 students. Parent permission forms were distributed and obtained for each child participating in this research.

General Procedures

The subjects participated in the experiment during their regular pre-school day between the hours of 9 A.M. and 11:30 A.M. The aptitude tests, treatments, pretest and posttest all followed this scheduling format. Since the students came from different schools, different socio-economic backgrounds and different races, they were randomly assigned to one of the three treatment groups.

TABLE 5
DISTRIBUTION OF SUBJECTS BY SEX AND AGE

Treatment Group	Number	Sex Male-Female		Age Mean	S D
Group 1 Verbal Didactic	30	12	18	4.61	.861
Group 2 Alternative Example	30	15	15	4 47	.862
Group 3 Placebo	30	16	14	4 63	947

After the [redacted] brief introduction to the experiment and practice sessions, the treatment sessions were conducted with groups of the children for this reason the instructions and practice examples were written so the instructor could maintain control over the information being given to each group

The pretest and posttest required that the instructor administer these tests to each student individually With the aid of three teachers who had been trained during the pilot study (Appendix A), the process was accelerated The instructions for the pretest and the posttest may be examined in the subsection Pretest, Posttest Measures of this chapter

Treatment Materials

Verbal Didactic Instruction

This condition utilized two nine block sets of "neutral" materials (Peters, 1970) Each set consisted of nine identical yellow, 1 3/4' x 1 3/4" x 7/8" wooden blocks which offered no specific cues for the establishment of one-to-one correspondence or for drawing the conservation inference. The subjects were requested to establish initial equivalence twelve times (twice on each training trial), and witnessed twelve different transformations during which the spatial arrangement was changed and then brought

back to the original position. Immediately following completion of each transformation and questioning sequence, a statement of the rule for conservation (adapted from Beilin, 1965) was given: "I have only moved the blocks. They are in another place, but there are just as many as before. See, I can put the whole bunch back the way they were. There are still the same number as before because I did not put in any more blocks or take away any blocks; I only moved them." As this statement was repeated, the blocks were returned to their original position. Each subject in this condition heard the rule twelve times.

Alternative Example Instruction (AEI)

This condition involved the same six trial procedures and same materials as the Verbal Didactic instruction treatment except that the students were asked to form an example of their own to illustrate each trial. Each student had a set of materials with which to make a comparative example. If correct, the instructor would reinforce the student; if incorrect he would aid the student in a correct solution. Each subject performed twelve trials and gave twelve Alternative Example responses.

Control

This condition involved the students in a task which was not related to the conservation performance. The control

(placebo) group was given some coloring worksheets and asked to color them. The time required for these activities was equal to the time required for the two previous treatments.

Methods of Data Collecting

The examiner recorded the IQ information with the aid of a trained assistant as prescribed by the WPPSI manual. The data was recorded on special forms provided with the WPPSI test materials. The Matching Familiar Figures Test information of latency score and number of errors were recorded on a data sheet shown in Appendix C. The pretest and posttest measures were recorded on a conservation record sheet shown in Appendix C. The total scores of the subjects were then transferred to a "computer summary sheet" (included in Appendix C). From these forms necessary data were transferred to IBM cards. Duplicate sets of data cards were made in order to facilitate data analysis and maintain data security. Key punching, scoring and analysis were performed by trained technicians under the direction of the experimenter.

CHAPTER III

RESULTS

The primary objectives of this study were to assess the acquisition of conservation of number and the alteration of conservation performance due to treatment, and to explore the effects of individual differences on learning from different modes of instruction.

This chapter describes the statistical tests of the hypotheses and the results achieved. The presentation of results first reports the instructional treatment main effects and then the Aptitude x Treatment Interactions. The analyses were computed using the University of Florida Statistical Programs Library and the SPSS Language Package.

Independent and Dependent Measures

Although conservation performance produced in preschool children by various treatments was of major interest in this study, of equal importance was an exploration of the possible effects of the aptitudes of IQ, impulsivity-reflectivity, latency score and error score to determine if they differentially interacted with student performance. The posttest performance on the conservation measure was treated as a dependent variable in this research.

Independent measures include those which potentially may predict a learner's performance relative to a specified instructional treatment. As presented in Table 6, this study included independent measures generally described as aptitudes. Dependent measures included evidence describing performance variables which were influenced in some way by experimental manipulation. In this study, the dependent measure (Table 8) was the posttest measure of conservation of number acquisition.

Intercorrelations Among Measures

Intercorrelations of both independent and dependent measures were compiled for the total sample. The intercorrelations among the measures are reported in Table 7.

The posttest conservation of number measure showed a slight correlation with the IQ aptitudes, the strongest being with the full scale IQ. The posttest measure for the full sample showed a negative correlation of -0.0531 with latency score and -0.1287 with error score. However, comparing the latency score correlation with posttest performance in Treatment Group 1 (Verbal Didactic) the correlation is .701* significant at the .002 level (Table 8). While the same relationship reported in Treatment Group 2 (Alternative Example) showed a correlation of -0.6328 significant at the .001 level (Table 9). This should indicate that the post-

test performance and the latency scores in both treatments contained some relationship.

The correlation of full scale IQ, verbal IQ and performance IQ yielded extremely high correlations as would be expected. The correlation between full scale IQ and verbal IQ was reported to be .8826, between full scale IQ and performance IQ to be .7018. The correlations between the aptitudes of IQ and latency score and error score were very low negatively correlated. This would indicate the IQ and latency and error scores do not have common areas of testing student aptitudes.

The correlation between latency score and error score was reported to be -0.3935. According to the previously reported studies correlation should have been more strongly negative (Tables 8, 9, 10). The research by Kagan (1970) and others have operated on the premise that a high latency score and a low error score would indicate that the subject was reflective. While a subject within low latency score and high error score would be labeled impulsive. Thus, a strong negative correlation between latency score and error score would be expected, such was not the case.

Distribution of Scores Within Measures

Means, standard deviations and distributions of both independent and dependent measures were compiled

TABLE 6
INDEPENDENT AND DEPENDENT MEASURES

INDEPENDENT MEASURES	DEPENDENT MEASURES
Performance IQ	Post-Test Measure
Verbal IQ	Conservation of Number
Full Scale IQ	
Latency Score	
Error Scale	
Pre-Test Measure	
Conservation of Number	

TABLE 7
INTERCORRELATIONS AMONG INDEPENDENT MEASURES AND DEPENDENT MEASURE

MEASURES	2	3	4	5	6	7	
1 Posttest (CN)	.3592	.2610	.2354	.1728	-0.0531	-0.1287	90
2 Pretest (CN)		.4235	.3852	.2832	-0.1609	-0.1166	90
3 Full Scale IQ			.8826	.7018	-0.2239	-0.1452	90
4 Verbal IQ				.3066	-0.2107	-0.0714	90
5 Performance IQ					-0.1723	-0.1469	90
6 Latency Score						-0.3935	90
7 Error Score							90

TABLE 3
INTERCORRELATIONS AMONG INDEPENDENT MEASURES AND DEPENDENT MEASURES

Treatment Group 1
Verbal Didactic

MEASURES		2	3	4	5	6	7	
1	Posttest (CN)	.0928	2261	2301	1703	7018	-0 1087	30
2	Pretest (CN)		4056	3696	.2840	-0 1555	-0 1090	30
3	Full Scale IQ			.8844	7020	-0 2300	-0 1420	30
4	Verbal IQ				3040	-0 2119	-0 0770	30
5	Performance IQ					0 1760	0 1420	30
6	Latency Score						0 3850	30
7	Error Score							30

TABLE 9
INTERCORRELATIONS AMONG INDEPENDENT MEASURES AND DEPENDENT MEASURES

Treatment Group 2
Alternative Example

MEASURES		2	3	4	5	6	7	8
1	Posttest (CN)	0836	.2582	2406	1864	-0 6328	-0 1032	30
2	Pretest (CN)		4321	3864	2808	-0 1620	-0 1190	30
3	Full Scale IQ			.8980	7002	-0 2250	-0 1510	30
4	Verbal IQ				3105	0 2050	-0 0800	30
5	Performance IQ					0 1725	-0 1500	30
6	Latency Score						-0 4090	30
7	Error Score							30

TABLE 10
INTERCORRELATIONS AMONG INDEPENDENT MEASURES AND DEPENDENT MEASURES

Treatment Group 3
Control

MEASURES	2	3	4	5	6	7	N
1. Posttest (CN)	.4682	.2847	.2388	.1710	-0.0433	-0.1374	30
2. Pretest (CN)		.4261	.3890	.2820	-0.1610	-0.1150	30
3. Full Scale IQ			.8810	.7010	-0.2260	-0.1460	30
4. Verbal IQ				.3050	-0.2120	-0.0690	30
5. Performance IQ					-0.1702	-0.1450	30
6. Latency Score						-0.3915	30
7. Error Score							30

for a total sample. The means and standard deviations for the independent variables are reported in Table 11. The means and standard deviations for the independent variables by treatment group are reported in Tables 12, 13 and 14. The frequency distributions of these scores by treatment group are presented in Appendix D. An inspection of these means, standard deviations and distributions indicated that most of the data did not appear to deviate from a normal distribution to warrant further testing.

Instructional Treatment Main Effects

The following hypotheses were of major concern relative to instructional treatment main effect:

1. There will be a significant positive influence on conservation performance for subjects who receive the Verbal Didactic method in instruction when compared with the performance of the control group.

2. There will be a significant positive influence on conservation performance for subjects who receive the Alternative Example method of instruction when compared with the performance of the control group.

3. There will be a significant positive influence on conservation performance for subjects who were typed impulsive or reflective.

4. There will be significant interaction between the type (impulsive-reflective) of student and the instructional treatment

Treatments were symbolized to make data table construction much clearer and less crowded. Thus the Verbal Didactic (VD), Alternative Example (AE) and Control (C) treatments may be identified by symbol notation. Subjects assigned to any one of the three treatments (described in Table 2) all completed the same posttest. It is on these posttest scores that the analysis for instructional main effects was performed.

Analysis of Covariance

All hypotheses were examined using scores obtained from the conservation of number test and comparing posttest scores of the treatment groups using analysis of covariance. In each case the pretest score for the same instrument was used as the covariate. Although subjects were randomly selected from an experimentally accessible population and were randomly assigned to experimental and control groups, the analysis of covariance design was used to control statistically any initial differences in conservation aptitude which might have been present and which might have confounded differences between the two groups. The selection of the analysis of covariance as a technique for testing differences between groups in research designs such as that used in this study is supported by Blomhoff

(1969) and Huck Cormier & Bounds (1974). These authors suggest that this technique may be used when the researcher can assume (a) that units are randomly assigned to treatment units; (b) that the covariate is measured without error, (c) that the covariate is independent of the treatment effect; (d) that the variance of the dependent variable at a given value of the covariate is constant across treatment groups and independent of the covariate; (e) that for each level of the covariate, the dependent variable is normally distributed; (f) that the covariate is linearly related to the dependent variable, and (g) that the regression of the dependent variable on the covariate is the same for each group.

Elashoff (1969) concluded that assumptions a, c, and g are critical to any interpretation of covariance analysis.

Thus, an analysis of covariance is a statistical procedure which attempts to reduce the error term as much as possible. In an analysis of variance (ANOVA) the variance associated with covariant 1 and covariant 2 in this study would be pooled with the error term in an ANOVA. In addition, an analysis of covariance removes what is thought of as "random" (unexplained) error and seeks to explain it. The ANOVA gives a true, or as true as possible, measure of the treatment effects of performance. In accordance with Kerlinger (1973) and Runyon & Haber (1971), when a significant F ratio occurred between two of the

TABLE II
MEANS AND STANDARD DEVIATIONS OF I NDEPENDENT VARIABLES

	PERFORMANCE MEASURE	n	Mean	S.D.
1	Pretest Conservation of Number	90	6.5111	3.1631
2	Performance IQ	90	103.5222	7.2132
3	Verbal IQ	90	104.7222	9.7213
4	Full Scale IQ	90	104.5333	7.8887
5	Latency Score	90	39.2755	14.2684
6	Error Score	90	10.1556	6.3120

TABLE 12
MEANS AND STANDARD DEVIATIONS OF INDEPENDENT VARIABLES

Treatment Group 1
Verbal Didactic

PERFORMANCE MEASURE	n	[illegible]	[illegible]
1. Pretest. Conservation of Number	30	6.567	3.431
2. Performance IQ	30	103.933	4.813
3. Verbal IQ	30	105.133	9.157
4. Full Scale IQ	30	104.767	6.23[illegible]
5. Latency Score	30	41.673	[illegible]
6. Error Score	30	9.833	6.781

TABLE 13
MEANS AND STANDARD DEVIATIONS OF INDEPENDENT VARIABLES

Treatment Group 2
Alternative Example

PERFORMANCE MEASURE	n	[illegible]	[illegible]
1. Pretest Conservation of Number	30	6.433	[illegible]
2. Performance IQ	30	103.700	[illegible]
3. Verbal IQ	30	105.[illegible]	[illegible]
4. Full Scale IQ	30	107.[illegible]	[illegible]
5. Latency Score	30	37.260	[illegible]
6. Error Score	30	10.000	[illegible]

TABLE 14
MEANS AND STANDARD DEVIATIONS OF INDEPENDENT VA[illegible]

Treatment Group 3
Control

PERFORMANCE MEASURE	n	Mean	S D
1. Pretest Conservation of Number	30	6 533	2 9[illegible]
2. Performance IQ	30	102 933	7.326
3. Verbal IQ	30	103.500	8.369
4 Full Scale IQ	30	103.567	8 131
5 Latency Score	30	38 893	14.739
6 Error Score	30	10 633	4.694

three treatment conditions a Tukey Honestly Significant Difference Test (HSD) should be compiled to determine the location of the significant difference

Acquisition of Conservation of Number

An inspection of the real means and standard deviations of the posttest questions, as reported in Table 15, identified potential between group differences relative to the performance of the treatment group and the control. The results of the analysis of covariance on the adjusted means for the posttest performances of the subjects are reported in a 3 x 3 treatment by type of analysis as reported in Table 16. The mean of Treatment I, the Verbal Didactic instruction, was reported to be 20.034, and Treatment 2, the Alternative Example instruction, was reported at 20.31%, while the control was only 6.846. With such a large difference between treatment means and the control group means, the analysis of covariance was computed. Significant between group differences were found for the main effects ($F = 107.52$, $P < .05$) and type (impulsive-reflective) ($F = 5.80$, $P < .05$). A comparison between pairs of treatment condition groups using the Tukey HSD (Honestly Significant Difference) test was performed and reported in Table 18

TABLE 15
REAL MEANS AND STANDARD DEVIATIONS OF POSTTEST QUESTIONS

PERFORMANCE MEASURE	n	Mean	S.D.
Posttest: Conservation of Number	90	15.7333	6.9758

BY TREATMENT GROUP	Treatment 1 (VD)			Treatment 2 (AE)			Treatment 3 (C)		
Performance Measure	n	Mean	S.D.	n	Mean	S.D.	n	Mean	S.D.
Posttest: Conservation of Number	30	20.100	2.657	30	20.200	3.089	30	6.90	2.791

TABLE 16
ADJUSTED MEANS FOR ANCOVA

Treatment x Type

	Treatment 1 Verbal Didactic	Treatment 2 Alternative Example	Treatment 3 Control	$\bar{x}$
Type 1 Impulsive Subjects	20.070	20.083	7.049	15.734 N = 33
Type 2 Reflective Subjects	19.675	19.789	6.730	15.402 N = 3
Type 3 Other Subjects	20.358	21.074	6.759	16.064 N = 23
$\bar{x}$	20.034 N = 30	20.319 N = 30	6.946 N = 30	

TABLE 17
ANALYSIS OF COVARIANCE SUMMARY TABLE (ANCOVA)

SOURCE	PROPORTION OF VARIANCE	ss	df	ms	F
Covariates: IQ-Pretest	.14	603.603	2	301.800	188.63*
Type Impulsive-Reflective-Other	.004	18.876	2	9.438	5.90*
Treatments: Verbal Didactic, Alternative Example, Control	.820	3454.468	2	1727.23	1079.52*
Interaction Treatment x Type	.001	4.217	4	1.054	.66
Residual	.035	126.437	79	1.60	
TOTAL	1.00	4207.600	89		

* $p < .05$

TABLE 18
TUKEY (WSD) TEST BETWEEN MEANS

	$\bar{x}_1$	$\bar{x}_2$	$\bar{x}_3$
$\bar{x}_1$ = 20.034	----	285	13 188
$\bar{x}_2$ = 20 319	----	——-	13 473
$\bar{x}_3$ = 6 846	——	-----	-----

WSD = 2.47

Thus, $\bar{x}_1$ vs $\bar{x}_3$

$\bar{x}_2$ va $\bar{x}_3$ are statistically significant at P .05,

while $\bar{x}_1$ vs $\bar{x}_2$ are not statistically significant at P .05

Overall Posttest Performance

Overall, posttest performance was calculated by counting the number of items correct on the conservation of number measure. The mean and standard deviation for the posttest performance for the entire sample is reported in Table 15. The means and standard deviations by treatment condition is reported in Table 15. As can be seen from the data in Table 15 there are larger differences between treatment and control. As reported in Table 17 this difference is very significant.

Aptitude x Treatment Interactions

The following hypothesis was of major concern relative to Aptitude x Treatment Interactions:

There will be a differential relationship between conservation performance and aptitudes of subjects relative to the treatment received.

Correlations of Ability Measures to Performance

One of the purposes of this study was to examine the effects of individual differences in relation to acquisition of conservation of number acquired from two different modes of instruction.

A first step in evaluating these theoretically expected relationships was to compute for each group separately the correlations between all aptitudes and the

posttest performance measures [illegible] correlations were then reassembled by posttest measure [illegible] that the correlations for a specified measure for all treatments would appear within the same table in order to facilitate inspection. These individual treatment group correlations are reported in Tables 7 through 10. Upon inspection it was apparent that in several instances the correlations between aptitudes and performance measures varied substantially across treatment conditions.

Evaluation for Aptitude x Treatment Interactions

The analysis of covariance yielded results to test the homogeneity of regression of the regression lines of the data in Table 17. The regression lines were significantly parallel and no interactions were found using the data in Table 17

CHAPTER IV

DISCUSSION AND IMPLICATIONS

Summary of Data: Hypotheses Tests

This study sought to examine the acquisition of conservation of number in preschool children and the effect of instruction on conservation of number performance. In addition, this study sought to examine conservation of number performance of preschool children using an Aptitude x Treatment Interaction (ATI) model in which the differential effects of impulsivity, reflectivity and verbal ability were examined in relation to Didactic and Alternative Example methods of instruction. Some basic premises of this study include the following:

1. The physical stimulus presented to the learner during instruction is not in simple correspondence to the effective stimulus encoded by the learner in that it is the effective stimulus which becomes the basis for subsequent psychological learning activity.

2. The various internal processing activities which contribute to the encoding of an effective stimulus can be influenced by elements in the physical stimulus. Therefore, acquisition of information from an instructional situation varies as a function of the prompts and cues included in the instructional material and environment.

3. The effectiveness of different instructional material varies from individual to individual with differences being correlated with individual aptitudes. (Wilson, 1973)

Specific predictions, although tentative, were based on theoretical considerations which suggest that requirements of different modes of instructional content were sufficiently different to produce different ability performance relationships. (Wilson, 1973)

Instructional Treatment Main Effects

Acquisition of Conservation of Number Using Verbal Didactic Instruction

The first hypothesis tested was

> 1. There will be a significant positive influence on conservation performance for subjects who receive the Verbal Didactic method of instruction when compared with the performance of the control group.

The acquisition of conservation of number by training procedures was the major purpose of this research. The posttest results reflect the performance of the subjects. Support for this hypothesis is dependent upon significant between group differences in scores on the posttest measure. The appropriate statistical tests of this hypothesis are therefore comparisons of posttest performances by pairs to treatment conditions following an overall significant F ratio. The data in Table 17 strongly supported this hypothesis.

In general, subjects who performed well on the conservation of number test (posttest) did not possess any unusually high verbal aptitude. The correlation

between verbal aptitude and posttest performance was reported to be .2301 (Table 8). This was an important factor in this research as other studies had indicated a strong influence of verbal aptitude and conservation performance, whereas, the results of this study indicate that verbal aptitude had little effect and conservation of number acquisition was considerably reduced.

In summary, the results of this study indicate that acceleration of the learning of conservation of numerical correspondence can be brought about through direct training. Additionally, methodological changes in the manner of collecting conservation data can reduce the interdependence upon verbal aptitude

Acquisition of Conservation of Number Using Alternative Example Instruction

The second hypothesis tested was

> 2. There will be a significant positive influence on conservation performance for subjects who receive the Alternative Example method of instruction when compared with the performance of the control group.

The acquisition of conservation of number by training procedures, as stated earlier, was the major purpose of this research. The posttest results of conservation performance by subjects who received the Alternative Example method of instruction indicated a significant difference when compared with the control group posttest scores (Table 17 and 18).

The Alternative Example method like the Verbal Didactic method, indicated no strong correlation between verbal aptitude and treatment (Table 9). This emphasizes the effect of methodological changes in the manner of collecting conservation of number data in reducing the interdependence on verbal aptitude.

In summary, both the Verbal Didactic instructions and the Alternative Example instructions prove equally strong ($\bar{x}_{VD}$ = 20.344 and $\bar{x}_{AE}$ = 20.319) in the acceleration of the learning of conservation of number. Secondly, neither of the instructional treatments was affected by the various aptitudes of IQ, e.g., performance IQ, verbal IQ and full scale IQ. Finally, it should be noted that there were no significant differences between the two treatments in assisting the students in acquiring conservation of number.

Impulsivity and Reflectivity Effects:

The third, fourth, and fifth hypotheses tested were:

3. There will be a significant positive influence on conservation performance for subjects who were typed impulsive or reflective.

4. There will be a significant interaction between the type (impulsive-reflective) of student and the instruction treatment.

5. There will be a differential relationship between conservation performance and aptitude of subjects relative to the treatment received.

The aptitude impulsivity or reflectivity to be considered influential on conservation of number performance in

dependent upon significant between group differences in the blocking variable type (impulsive-reflective-other). The data reported in Table 17 indicated that type was only slightly significant ($F = 5.90$, $P < .05$) and only accounted for .004 of the total variance in conservation posttest scores. In addition, the treatment x type interaction showed no significant interaction (Table 17). The homogeneity of the regression test from the analysis of covariance indicated that the regression lines of all the variables were significantly parallel.

In summary, on the surface, the evidence collected does not generally support hypotheses 3, 4, and 5. However, upon further investigation, some serious methodological problems of categorizing subjects as either impulsive or reflective were revealed. Two statistical characteristics are the source of methodological problems of the MFF for its use in research on reflectivity-impulsivity. The troublesome characteristics are the low reliability of error scores and the moderate negative correlation between latency and errors. (Ault, 1973). Reliability, both test-retest and internal consistency, has been almost completely neglected by researchers using the MFF with elementary school children. The test-retest reliabilities for error scores range from .23 to .43, while test-retest reliability of latency ranges from .62 to .82. (Ault, 1973)

[illegible] the latency-error correlation which averages -.56. This moderate correlation poses serious difficulties for typical 2 x 2 analyses of variance performed on some dependent variable for subjects from the MFF classifications. Using high versus low errors and high versus low latencies as the two factors in an analysis of variance results in confounded main and interaction effects, since errors and latencies are not orthogonal (Kahneman, 1965). Also using two factors which are correlated will result in unequal cell sizes unless some subjects are discarded. (With a correlation between latency and errors of -.56, about one-third of the subjects fall into each of the reflective and impulsive cells and the remaining one-third are labeled others.) This makes interpretation of any interactions very difficult (McNemar, 1969), and cell means are not equally stable.

In 2 x 2 as well as simpler designs, such as those using only two of the MFF categories, dichotomizing errors and latency scores produce still another problem. Artificially dichotomizing the continuous variables of latency and error by median splits and then subjecting the categorical scores to ANOVA procedures squanders information and results in a substantial loss of statistical power. (Cohen, 1968). A more appropriate and more powerful method is to maintain error and latency scores in their

continuous form and apply multiple regression methods. (Kerlinger & Pedhazur, 1971)

This information and a reexamination of Tables 7, 8, 9, and 10 indicated that an additional analysis of covariance should be performed replacing the variable type with latency score and error score. In Table 7 the intercorrelation between posttest performance and latency score was reported to be -0.0531, and posttest performance and error score was reported to be -0.1287. In Table 8 the intercorrelation between posttest performance and latency score was reported to be .7018 and posttest performance and error score was reported to be -0.1087. In Table 9 the intercorrelation between posttest performance and latency score was reported to be -0.6328 and posttest performance and error score was reported to be -0.1032. In analyzing these results, it should be clear that some interaction was occurring between subjects with high latency scores receiving the Verbal Didactic method of instruction. Likewise, some interaction was occurring between subjects with low latency scores receiving the Alternative Example method of instruction.

This prompted another analysis of covariance to be performed on the posttest conservation scores using latency score and error score as continuous variables and the results are reported in Tables 19 and 20. Using the variables of latency and error score as continuous variables

permitted the testing of hypotheses four and five. It can be seen that the mean score for the Alternative Example method (22.823) is greater than the mean score for the Verbal Didactic method (16.420) as reported in Table 19, and are much different than those reported in Table 18. In Table 20 the main focus should be on the interaction between latency and treatment which was very significant F = 60.31 ($P < .05$). Using latency score and error score as continuous variables increased the significance of the main effects from F = 1079.52 ($P < .05$) to F = 2829.60 ($P < .05$) and the significance of the covariates were increased from F = 188.62 ($P < .05$) to F = 494.75 ($P < .05$). These increases would not alter the conclusions of the researcher but the significance of the interaction between treatment and latency score is consistent with Solomon's (1972) heuristic ATI model. Where treatments designed on a compensatory basis would be expected to help low ability learners by compensating for abilities in which they are lacking, high ability students would not be expected to benefit appreciably from such treatments and may actually be hindered

TABLE 19
ADJUSTED MEANS FOR ANALYSIS OF COVARIANCE (ANCOVA)
CONTINUOUS VARIABLE

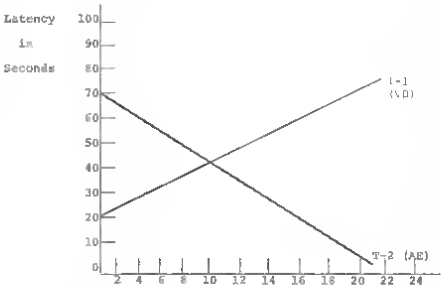
	Treatment 1 Verbal Didactic	Treatment 2 Alternative Example	Treatment 3 Control
$\bar{X}$	16.420	22.823	7.812
	N = 30	N = 30	N = 30

TABLE 20
ANALYSIS OF COVARIANCE (ANCOVA) TYPE AS A CONTINUOUS VARIABLE

SOURCE	PROPORTION OF VARIANCE	ss	df	ms	
Covariates					
IQ-Pretest	.144	603.603	2	301.80	494.70*
Type					
Latency Score	.001	3.054	1	3.05	5.00*
Error Score	.005	20.916	1	20.91	34.27*
Treatments					
Verbal Didactic, Alternative Example, Control	.821	3452.134	2	1726.06	2829.60*
Interaction.					
Treatment x Latency	.018	74.320	2	37.16	60.91*
Treatment x Error	.000	.167	2	.08	.13
Trends	.001	5.678	2		6.27*
Residual	.011	47.726	77	.61	
TOTAL	1.00	4207.587	89		

* P < .05

INTERACTION OF LATENCY SCORE WITH
POSTTEST PERFORMANCE



VD = .92x + 20 8

AE = - 62x + 69 3

FIGURE 5

Conclusion and Discussion

This investigation suggests that conservation of number can be taught to children in the preoperational period. Much of the literature discussed in Chapter I indicates that conservation performance is static and can not be obtained through accelerated instruction. Moreover, that in the few cases where it was obtained, it dissipated rapidly upon the absence of instruction. The pilot study (Appendix A) indicated that the conservation performance of preschool children did not dissipate with time. This study should indicate that the conservation of number can be accelerated in preschool children with proper instructional methods. As discussed in Chapters II and III, one of the major methodological implications of this research has been the materials used for examining the preschool children for conservation acquisition. This research may lead to further refinements of such instruments to improve upon the reliability in obtaining an accurate assessment of conservation performance in young children.

This investigation suggests that latency score and the instructional treatments approach the heuristic model in ATI research known as the compensatory model (Solomon, 1972). The compensatory model is a model in which treatments are designed to compensate for the particular aptitude deficiencies of some learners.

Examining Figure 5, we can see that students with high latency scores performed better than students with low latency scores in the Verbal Didactic treatment while students with low latency scores performed better than students with high latency scores in the Alternative Example method of instruction.

One can interpret a positive slope (Figure 5, VD) as indicating that a treatment capitalizes on an ability while a negative slope (Figure 5, AE) suggests that a treatment capitalizes on a different ability, thus a negative slope suggests that a treatment compensates for a low ability and is dysfunctional for high ability students.

In addition, the findings of this investigation suggest important methodological implications. A question format using more than one question about each transformation and possibly varying the order of the questions asked, and the inclusion of a variety of transformations measuring conservation of both equality and inequality, seem essential for gaining an accurate picture of the child's conservation status. In addition, the student's explanations of their judgments might also be obtained in greater depth where possible, although the weight that verbalized judgments should be given in establishing conservation status is still in question. By including some of the considerations mentioned above, future investigations of the conservation phenomena might profit by having increased precision and reliability in their measuring instruments.

All of the problems mentioned in this paper might lead an MFF researcher to despair. However, it is not suggested that the MFF be discarded. It's validity has been demonstrated over a wide variety of tasks which measure cognitive development. Use of larger sample sizes, adequate research designs and appropriate statistical analyses makes it possible to continue to work with the test in it's present form. Moreover, further refinements in the test may improve it's reliability. It is suggested that investigators be more careful in interpreting their results. Consistent failures to influence error scores significantly would be due to the loss of power connected with the test's low error reliability rather than some characteristic of error rates per se. Past research should be reevaluated in light of these methodological considerations, and future research should be designed with all of the MFF's strengths and weaknesses in mind.

APPENDICES

APPENDIX A

PILOT STUDY

THE PROBLEM

Statement of the Problem

This study focuses its attention on diagnosing the presence of conservation aptitudes in subjects determined to be in the Piagetian preoperational period and examines conserving performance of preschool children (Ages: 3.0 - 5.8) using an Aptitude x Treatment Interaction (ATI) model in which the differential effects of impulsivity-reflectivity, cognitive style and verbal ability are examined in relation to Didactic method of instruction.

Statement of Hypotheses

Based upon the previously reviewed research and theory, the following hypotheses are to be tested:

1. There will be a significant influence on conservation performance for subjects who receive the Verbal Didactic method of instruction when compared with the performance of the control group.

2. There will be a differential relationship between conservation performance and aptitudes of subjects relative to the treatment received.

Method

Subjects

The subjects were 120 preschool children attending the Andromeda School (a private non-profit school) in Gainesville, Florida. Permission forms were distributed and returned by all participants in this study. The mean age of the students was 49 months with a range of 29 to 71 months. The subjects were divided into three age groups. (1) Group A - 29 to 35 months; (2) Group B - 36 to 47 months, and; (3) Group C - 48 to 71 months. Subjects were randomly selected from each of the three groups (A, B, C) and assigned to a treatment.

Materials and Procedure

All students were given a group of four tests two weeks prior to the treatment.

1. Verbal Ability (VA) - WPPSI Vocabulary and Information Subtests - The Vocabulary and Information scales of the Wechsler Preschool and Primary Scale of Intelligence (WPPSI) was administered and scored in the usual fashion. Birth dates were obtained from school records and scaled scores were computed. The prediction validity, as assessed by later performance on achievement tests, appeared to be better for the WPPSI than for the Stanford-Benet, Peabody, Bender-Gestalt or Draw-A-Person

(Pokecki, Frede & Gantney, 1961). Reliability estimates ranged from .71 to .94 depending on the subtest and age group, the verbal subtest being the most reliable of the age range .86 to .94.

2. Cognitive Style (CS) - The sorting task used for determining the subject's preferred categories of sorting behavior was developed by Educational Testing Service (Charlesworth, 1968). Using a standard array of 25 three dimensional objects, each subject was asked to make five cued sorts and five free sorts, with the number of objects in each pair of sorts increased by five (5, 10, 15, 20, 25). The order of cued versus non-cued sorts was counterbalanced. The subjects were instructed to put together all the things that "go together with, or belong with" the cue object, or, in the case of the free sort situations, all the things which "go together or belong together". The subject's reason for each sort was elicited and this along with the objects used, and the order of their use, was recorded.

For the analysis four major categories were used.

A. Analytic - In this category were scored all groupings built upon similarity in objective elements, within a stimulus complex, that were a part of the total stimulus. The element(s) selected as the shared basis

of similarity between two or more objects was a differential part of the stimulus whole.

B. Relational - Counted in this category were groupings built upon a functional relationship between or among the grouped objects. No one object was an independent instance of the concept used for grouping. The objects so organized were seen as interacting with each other or being found in the same context.

C. Conceptual - Groupings here were organized on the basis of common class membership, or functional usage. Any object in the group was an independent instance of the conceptual label.

D. Other - This category included all sorts not classifiable under the other three categories.

3. Matching Familiar Figures Test - (MFF) - This is a standard instrument devised by Kagan et al. (1964) to assess cognitive tempos in children. The version of the test which was administered in this study was the preschool version designed for children ages 2;7 to 6.9 (Kagan, 1966). The MFF measures a child's tendency to have a reflective or impulsive cognitive style. On this task a child looks at one standard stimulus line drawing and must point out an exact match from among six alternatives. He is scored for response latency (time from exposure to first response) and number of errors on each of twelve trials. A child who is

below the group median on response time and above the group median on errors is considered impulsive. A child who is above the median on response time and below the median on errors is considered reflective. Reliability, both test-retest and internal consistency, has been reported by researchers using the MFF with elementary and preschool children (Kagan, 1965, 1966; Denney, 1973). The range for test-retest reliability was reported as being .62 to .73 depending on the age of the child (Kagan, 1966; Denney, 1973). The range of coefficient alphas were reported to range from .67 to .78.

4. Measure of Conservation of Number (CN) - Conservation of number is a Piagetian task measure consisting of 24 items, twelve using a top-bottom orientation and twelve using a bottom-top orientation. A Point-Biserial correlation was used to measure the relationship of items to total test score and evaluate the overall reliability of the instrument. The test was administered to a group of forty preschool students (none of which were subjects for this research) to determine the reliability of the instrument. The reliability was .82 and the correction between the twelve, thus, was .57

TABLE 21
RESEARCH DES[illegible]

				Posttest		
				30 Days	60 Days	90 Days
R_1	Pretest (O_1)	Verbal Didactic (Z)	Posttest (O_3)	(O_6)	(O_9)	(O_{12})
R_2	Pretest (O_2		Posttest (O_4)	(O_7)	(O_{10})	(O_{13})
R_3			Posttest (O_5)	(O_8)	(O_{11})	(O_{14})

TABLE 22
RESEARCH DESIGN

This gives a modified Solomon 4 Group Matrix with a times series feature.

R_1	O_1	X_V	O_3	O_6	O_9	O_{12}
R_2	O_2		O_4	O_7	O_{10}	O_{13}
R_3			O_5	O_8	O_{11}	O_{14}

Design

The students were randomly assigned to three groups. Group One received the pretest, Verbal Didactic instructionand posttest Group Two received the pretest and the posttest only Group Three received the posttest only. All students were tested 30 days, 60 days and 90 days after the original treatment The design is illustrated in Tables 21 and 22

Verbal Didactic Instruction (x_v) - The instructor took each of the students through a series of conservation exercises using an identical set of ten wooden beads. The instructor set up examples in which the student established one-to-one correspondencss while setting up similar examples. Immediately following the completion of each transformation and question sequence, a statement of the rule of conservation was stated by the instructor, such as, "We had the same number of beads; we only moved the beads to different positions." At the end of this statement the beads were returned to their original positions where one-to-one correspondence could be easily viewed by the students The emphasis of instruction was that each of the five tasks, as illustrated in Tables 21 and 22, was taken irrespective of any hierarchial ordering system.

Results

Impulsive-Reflective Split - Using the scores obtained on the MFF test the students were classified

TABLE 23
CONCEPTUAL STYLE AGE DISTRIBUTION

	AGE			TOTAL
	Group A (29-35 Mo.)	Group B (36-47 Mo.)	Group C (48-71 Mo.)	
ANALYTIC	2	14	27	[illegible]
RELATIONAL:	8	10	2	[illegible]
CONCEPTUAL	9	12	10	[illegible]
OTHER*	1	4	2	[illegible]
	20	40	60	[illegible]

TABLE 24
VERBAL SCORE AND INTELLIGENCE SCORE (IQ)

IQ, Verbal Score:

	Group A	Group B	Group C
	$\bar{x}$	$\bar{x}$	$\bar{x}$
IQ	75	102	110
Verbal	78	105	108

IQ, Verbal Score (by Treatment Group):

	Group A	Group B	Group C
	$\frac{x_v}{x}$	$\frac{x_1}{x}$	$\frac{x_2}{x}$
IQ	104	107	109
Verbal	106	105	104

TABLE 25
CONSERVATION OF NUMBER TEST SCORES BY AGE GROUPS

	Pretest Score		Posttest Score		20 Days		60 Days		90 Days	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Group A (29-35 Mo):	3.25	2 80	5 65	3 16	5.25	2 80	4.90	3 25	4 80	3.16
Group B (36-47 Mo)	6.03	2 65	17 41	3 05	18.20	3 15	18 28	3 07	18 60	3.22
Group C (48-71 Mo.)	6.58	2 88	22.73	2 20	22 89	2.10	22 90	2.06	22.92	1.96

as impulsive or reflective. The impulsive group included those students who scored at or below the medium on errors. The reflective group included those who scored above the medium on response and below the medium on errors. The medium response time for Group B (46 students) was 32 seconds, and the medium errors was 28. The medium response time for Group C (54 students) was thirteen seconds and the medium of errors was nineteen. In Group A none of the students could be judged to be either impulsive or reflective. In Group B ten subjects were judged to be impulsive and eight reflective. In Group C twelve subjects were judged to be impulsive and thirteen reflective. The subjects in the impulsive and reflective groups were selected at random from each group for the experimental treatments.

Cognitive Style - All 120 students were tested using the ETS measure for cognitive style. The results are displayed in Table 23.

Measure of Conservation of Number (CN) - A number conservation test was administered to the students as described in the Experimental Design. The number conservation test was 24 questions in length, twelve sets of questions reversing the order of the responses to clearly mark the level of conservation, and add to the reliability of the measure. The test had been administered previously

to determine its reliability and perform an item analysis. The test was administered to 36 students of the same age randomly selected from a different school. The reliability was found to be .88.

A one-way analysis of variance (ANOVA) was performed comparing treatment groups and mean test scores on the conservation of numbers test. As predicted, the Didactic treatment group scored significantly higher, $F(2,279) = 103.79$ ($P < .01$). A four-way analysis of variance design was utilized to compare cognitive style and conservation test scores. The Newman-Kuels test (which is more conservative than the t test when more than two means are compared) showed that analytical students were significantly better conservers than the remaining three groups, $F = 35.92$ ($P < .001$). In addition, relational students were better conservers than the remaining groups, $F = 16.84$ ($P < .001$). The conceptual and other groups showed little difference on the conservation measure, $F = .001$ ($P < .05$).

An ANOVA was performed on IQ and verbal score x conservation test score. The results were not significant. An analysis of variance was performed comparing age and conservation test score. The older group showed a significant difference, $F = 54.89$ ($P < .01$).

The MFF test revealed that 22 subjects were impulsive and 21 were reflective. The reflective students did

significantly better on [illegible] than the impulsive students, $F = 62.60$ ($P < .01$). However the impulsive students who were in the Didactic treatment group performed better than the impulsive students that were in the control group $F = 8.26$ ($P < .05$).

Discussion

The data from this study indicated that conservation of number is related to chronological age of children. The older children did perform significantly better than their younger counterparts. In addition, the learning of number conservation seems to have more stability of time with older children.

The significant differences between the treatment and control groups suggests that conservation of number can be taught; moreover, it does not diminish as a function of time. The stability of this learning is most important, as many other Piagetian researchers have suggested that Piagetian tasks can only be acquired through maturation.

The data from this study indicates that conservation of number is related to cognitive style and that analytical and reflective students perform best.

The most significant feature of this study has been the development of the conservation of number instrument. In the past, the conservation of number has been tested by one of two examples administered verbally and inconsistently to students. This measure provides a reliable

method of obtaining the child's conservation of number level. If conservation of number and of other areas is significant in the learning process, then it should be accurately assessed in teaching methods developed to gain proficiency

APPENDIX B

CONSERVATION OF NUMBER TESTS

CONSERVATION OF NUMBER TEST

Question Number		Visual Display					
1.	S:	D	0	0	0	0	
	E:		0	0	0	0	D
	(E-Row Manipulated)						
2.	S:		0	0	0	0	0
	E:	0	0	0	0	0	
	(E-Row Manipulated)						
3.	S:	0	0	0	0	0	
	E:			00000			
	(E-Row Manipulated)						
4	S:	0	0	0	0	0	
	E:	0000			0		
	(E-Row Manipulated)						
5.	S:	0	0	0	0	0	
	E:		0000		0		
	(E-Row Manipulated)						
6	S:	0	0	0	0	0	
	E:		00		000		
	(E-Row Manipulated)						
7.	S:	0	0	0	0	0	
	E:	000		00			
	(E-Row Manipulated)						

Question Number	Visuel Display
8.	S: 0 0 0 0 0 E: 0 0 0 0 0 (E-Row Manipulated)
9.	S: 0 0 0 0 E: 0 0 0 0 arrows indicate added elements (E-Row Manipulated)
10.	S: 0 0 0 0 E: 0 0 0 0 arrows indicate subtracted elements (E-Row Manipulated)
11	S: 0 0 0 0 0 E: 0 0 0 0 arrows indicate subtracted elements (E-Row Manipulated)
12	S: 0 0 0 0 0 E: 0 0 0 0 arrows indicate added elements (E-Row Manipulated)
13	S: 0 0 0 0 0 E: 0 0 0 0 0 (S-Row Manipulated)
14	S: 0 0 0 0 0 E: 0 0 0 0 0 (S-Row Manipulated)

Question
Number

15 [illegible] 00000

S 0 0 0 0 0

(S-Row Manipulated)

16 S 0000 0

E 0 0 0 0 0

(S-Row Manipulated)

17 S 0000 0

E 0 0 0 0 0

(S-Row Manipulated)

18 S 00 000

E 0 0 0 0 0

(S-Row Manipulated)

19 S: 000 00

E 0 0 0 0 0

(S-Row Manipulated)

20 S: 0 0 0 0 0

E: 0 0 0 0 0

(S-Row Manipulated)

21 S 0 0 0 0

E: 0 0 0 0

(S-Row Manipulated)

Arrows indicate added elements

22 S: 0 0 0 0

E 0 0 0 0

(S-Row Manipulated)

Arrows indicate subtracted elements

Question
Number

23. S: 0 0 0 0

b: 0 0 0 0 0

arrows indicate subtracted elements

(S-Row Manipulated)

24. S: 0 0 0 0

a: 0 0 0 0 0

arrows indicate added elements

(S-Row Manipulated)

APPENDIX C

INSTRUMENT FORMS

MATCHING FAMILIAR [illegible]

Code _____ Sex _____ Ag _____

Date _____ Time _____ Examiner _____

ITEM	FIGURE					TIME (sec)	NO. OF ERRORS
1	House	1	(2)	3	4		
2	Bottle	1	2	3	(4)		
3	Apple	1	2	(3)	4		
4	Hat	1	2	3	(4)		
5	Shoe	1	(2)	3	4		
6	Dog	1	2	(3)	4		
7	Cup	1	2	(3)	4		
8	Tree	1	2	3	(4)		
9	Flower	1	2	(3)	4		
10	Face	(1)	2	3	4		
11	Chair	1	(2)	3	4		
12	Ball	1	(2)	3	4		
13	Star	(1)	2	3	4		

Total Time _____

Total Errors _____

CONSERVATION OF NUMBER SCORE SHEET

Circle number one if correct, number zero if incorrect

ITEM	RESPONSE	
1	1	0
2	1	0
3	1	0
4	1	0
5	1	0
6	1	0
7	1	0
8	1	0
9	1	0
10	1	0
11	1	0
12	1	0
13	1	0
14	1	0
15	1	0
16	1	0
17	1	0
18	1	0
19	1	0
20	1	0
21	1	0
22	1	0
23	1	0
24	1	0

TOTAL SCORE

DATA SUMMARY SHEET

Student Code _____ Treatment Group _____

Pretest Score	Posttest Score	Performance IQ	Verbal IQ	Full Scale IQ	Latency Score	Error Score	Reflective Impulsive	Age in Months	Sex

APPENDIX D

SUMMARY TABLES BY TREATMENT

TABLE 26
PRETEST FREQUENCIES

Treatment 1 (VD)

Pretest Score	Absolute Freq	Relative Freq (PCT)	Adjusted Freq (PCT)	Cum Freq. (PCT)
2	3	10.0	10.0	10.0
3	4	13.3	13.3	23.3
4	2	6.7	6.7	30.0
5	7	23.3	23.3	53.3
6	2	6.7	6.7	60.0
8	2	6.7	6.7	66.7
9	1	3.3	3.3	70.0
10	4	13.3	13.3	83.3
11	2	6.7	6.7	90.0
12	2	6.7	6.7	96.7
13	1	3.3	3.3	100.0
TOTAL	30	100.0	100.0	

TABLE 27
POSTTEST FREQUENCIES

Treatment 1 (VD)

Posttest Score	Absolute Freq	Relative Freq. (PCT)	Adjusted Freq. (PCT)	Cum Freq (PCT)
13	1	3.3	3.3	3.3
15.	1	3.3	3.3	6.7
16.	1	3.3	3.3	10.0
17	1	3.3	3.3	13.3
18	3	10.0	10.0	23.3
19	3	10.0	10.0	33.3
20	7	23.3	23.3	56.7
21	4	13.3	13.3	70.0
22.	3	10.0	10.0	80.0
23.	3	10.0	10.0	90.0
24.	3	10.0	10.0	100.0
TOTAL	30	100.0	100.0	

TABLE 2F
PERFORMANCE IQ FREQUENCIES

Treatment 1 (VD)

Performance IQ	Absolute Freq	Relative Freq (PCT)	Adjusted Freq (PCT)	Cum Freq (PCT)
100	14	46.7	46.7	46.7
102	1	3.3	3.3	50.0
103	1	3.3	3.3	53.3
104	1	3.3	3.3	56.7
105	5	16.7	16.7	73.3
106	1	3.3	3.3	76.7
107	2	6.7	6.7	83.3
108	1	3.3	3.3	86.7
114	4	13.3	13.3	100.0
TOTAL	30	100.0	100.0	

TABLE 29
VERBAL IQ FREQUENCIES

Treatment 1 (VD)

Verbal IQ	Absolute Freq.	Relative Freq. (PCT)	Adjusted Freq. (PCT)	Cum. Freq. (PCT)
87.	1	3.3	3.3	3.3
95	2	6.7	6.7	10.0
96	1	3.3	3.3	13.3
99.	2	6.7	6.7	20.0
100	4	13.3	13.3	33.3
101.	3	10.0	10.0	43.3
102.	3	10.0	10.0	53.3
104	1	3.3	3.3	56.7
105	2	6.7	6.7	63.3
106	1	3.3	3.3	66.7
107.	1	3.3	3.3	70.0
111	2	6.7	6.7	76.7
112	1	3.3	3.3	80.0
114	4	13.3	13.3	93.3
125	1	3.3	3.3	96.7
132	1	3.3	3.3	100.0
TOTAL	30	100.0	100.0	

TABLE 30
FULL SCALE IQ FREQUENCIES

Treatment 1 (VD)

Full Scale IQ	Absolute Freq	Relative Freq (PCT)	Adjusted Freq (PCT)	Cum Freq (PCT)
90	1	3.3	3 3	3 3
97	1	3 3	3 3	6 7
98	1	3.3	3 3	10 0
99	2	6 7	6 7	16.7
100	3	10 0	10.0	26.7
101	2	6.7	6.7	33.3
102	2	6 7	6 7	40.0
103.	1	3.3	3.3	43.3
104	1	3.3	3 3	46.7
105	3	10.0	10.0	56.7
106	3	10.0	10.0	66.7
107	1	3.3	3.3	70 0
108	1	3 3	3 3	73 3
109	1	3.3	3.3	76 7
110	4	13 3	13 3	90 0
111	1	3 3	3.3	93.3
119	1	3.3	3.3	96.7
120	1	3.3	3.3	100 0
TOTAL	30	100.0	100 0	

TABLE 31
TYPE OF FREQUENCIES

Treatment 1 (VD)

Code	Absolute Freq.	Relative Freq (PCT)	Adjusted Freq (PCT)	Cum. Freq (PCT)
Reflective	11	36.7	36.7	36.7
Impulsive	12	40.0	40.0	76.7
Other	7	23.3	23.3	100.0
TOTAL	30	100.0	100.0	

TABLE 32
ERROR SCORE FREQUENCIES

Treatment 1 (VD)

Error Score	Absolute Freq	Relative Freq (PCT)	Adjusted Freq (PCT)	Cum Freq (PCT)
2	4	13.3	13.3	13.3
3	1	3.3	3.3	16.7
4	3	10.0	10.0	26.7
5	1	3.3	3.3	30.0
6	2	6.7	6.7	36.7
7	1	3.3	3.3	40.0
8	3	10.0	10.0	50.0
9	1	3.3	3.3	53.3
10	3	10.0	10.0	63.3
11	1	3.3	3.3	66.7
12	3	10.0	10.0	76.7
14	1	3.3	3.3	80.0
15	1	3.3	3.3	83.3
18	2	6.7	6.7	90.0
20	1	3.3	3.3	93.3
26	1	3.3	3.3	96.7
27	1	3.3	3.3	100.0
TOTAL	30	100.0	100.0	

TABLE 33
PRETEST FREQUENCIES

Treatment 2 (AE)

Pretest Score	Absolute Freq	Relative Freq (PCT)	Adjusted Freq (PCT)	Cum Freq (PCT)
2.	2	6.7	6.7	6.7
3.	5	16.7	16.7	23.3
4.	3	10.0	10.0	33.3
5.	4	13.3	13.3	46.7
6.	3	10.0	10.0	56.7
7.	3	10.0	10.0	66.7
8.	2	6.7	6.7	73.3
9.	2	6.7	6.7	80.0
10.	2	6.7	6.7	86.7
11.	1	3.3	3.3	90.0
12.	1	3.3	3.3	93.3
13.	2	6.7	6.7	100.0
TOTAL	30	100.0	100.0	

TABLE 34
POSTTEST FREQUENCIES

Treatment 2 (AE)

Posttest Score	Absolute Freq.	Relative Freq (PCT)	Adjusted Freq (PCT)	Cum Freq.(PCT)
12.	1	3.3	3.3	3.3
14.	1	3.3	3.3	6.7
15.	1	3.3	3.3	10.0
16.	1	3.3	3.3	13.3
17.	1	3.3	3.3	16.7
18.	2	6.7	6.7	23.3
19.	2	6.7	6.7	30.0
20.	5	16.7	16.7	46.7
21.	7	23.3	23.3	70.0
22.	1	3.3	3.3	73.3
23.	3	10.0	10.0	83.3
24.	5	16.7	16.7	100.0
TOTAL	30	100.0	100.0	

TABLE 35
PERFORMANCE IQ FREQUENCIES

Treatment 2 (AE)

Performance IQ	Absolute Freq.	Relative Freq. (PCT)	Adjusted Freq. (PCT)	Cum. Freq (PCT)
80.	1	3.3	3.3	3.3
86.	2	6.7	6.7	10.0
92.	1	3.3	3.3	13.3
100.	6	20.0	20.0	33.3
101.	1	3.3	3.3	36.7
102.	4	13.3	13.3	50.0
103.	1	3.3	3.3	53.3
105.	2	6.7	6.7	60.0
106.	1	3.3	3.3	63.3
107.	1	3.3	3.3	66.7
108.	1	3.3	3.3	70.0
111.	1	3.3	3.3	73.3
114	7	23.3	23.3	96.7
115.	1	3.3	3.3	100.0
TOTAL	30	100.0	100.0	

TABLE 36
VERBAL IQ FREQUENCIES

Treatment 2 (AE)

Verbal IQ	Absolute Freq.	Relative Freq. (PCT)	Adjusted Freq. (PCT)	Cum. Freq. (PCT)
81.	1	3.3	3.3	3.3
87.	1	3.3	3.3	6.7
90.	1	3.3	3.3	10.0
94.	1	3.3	3.3	13.3
96.	1	3.3	3.3	16.7
99.	1	3.3	3.3	20.0
100	5	16.7	16.7	36.7
101	2	6.7	6.7	43.3
102	1	3.3	3.3	46.7
106.	1	3.3	3.3	50.0
107.	3	10.0	10.0	60.0
108.	1	3.3	3.3	63.3
109.	1	3.3	3.3	66.7
111.	1	3.3	3.3	70.0
112.	2	6.7	6.7	76.7
114.	3	10.0	10.0	86.7
119.	1	3.3	3.3	90.0
121	1	3.3	3.3	93.3
122.	1	3.3	3.3	96.7
132.	1	3.3	3.3	100.0
TOTAL	30	100.0	100.0	

TABLE 37
FULL SCALE IQ FREQUENCIES

Treatment 2 (AE)

IQ	Absolute Freq.	Relative Freq (PCT)	Adjusted Freq. (PCT)	Cum Freq (PCT)
78.	1	3.3	3.3	3 3
87.	1	3 3	3 3	6 7
89	1	3 3	3 3	10 0
98.	1	3.3	3 3	13 3
99.	1	3 3	3.3	16.7
100.	4	13.3	13.3	30 0
104.	1	3 3	3 3	33.3
105.	3	10 0	10 0	43.3
106	2	6 7	6 7	50.0
108.	3	10 0	10 0	60.0
109.	4	13.3	13.3	73.3
110.	2	6-7	6-7	80 0
111.	1	3 3	3 3	83.3
112.	1	3.3	3.3	86.7
114	1	3 3	3 3	90.0
119	1	3 3	3.3	93.3
120	2	6.7	6-7	100-0
TOTAL	30	100-0	100-0	

TABLE 3#
TYPE OF FREQUENCIES

Treatment 2 (AE)

Code	Absolute Freq.	Relative Freq. (PCT)	Adjusted Freq (PCT)	Cum Freq (PCT)
Reflective	12	40.0	40.0	40.0
Impulsive	12	40.0	40.0	80.0
Other	6	20.0	20.0	100.0
TOTAL	30	100.0	100.0	

TABLE 39
ERROR SCORE FREQUENCIES

Treatment 2 (AE)

Error Score	Absolute Freq	Relative Freq.(PCT)	Adjusted Freq (PCT)	Cum Freq (PCT)
0	1	3 3	3 3	3 3
1	1	3.3	3.3	6.7
2	4	13 3	13.3	20.0
3	2	6 7	6 7	26.7
4	1	3.3	3.3	30.0
7	2	6.7	6 7	36.7
8	3	10.0	10.0	46.7
9	3	10.0	10.0	56.7
10	3	10 0	10 0	66 7
11	1	3 3	3 3	70.0
13	1	3 3	3 3	73 3
14	1	3 3	3 3	76.7
18	2	6.7	6.7	83.3
20	3	10.0	10 0	93.3
24	1	3.3	3 3	96.7
28	1	3.3	3 3	100.0
TOTAL	30	100 0	100 0	

TABLE 40
PRETEST FREQUENCIES

Treatment 3 (C)

Performance Score	Absolute Freq	Relative Freq (PCT)	Adjusted Freq (PCT)	Cum Freq (PCT)
2.	1	3.3	3.3	3.3
3.	4	13.3	13.3	16.7
4	3	10.0	10.0	26.7
5.	4	13.3	13.3	40.0
6.	5	16.7	16.7	56.7
7	2	6.7	6.7	63.3
8.	5	16.7	16.7	80.0
9.	1	3.3	3.3	83.3
10.	1	3.3	3.3	86.7
11.	2	6.7	6.7	93.3
12.	1	3.3	3.3	96.7
13.	1	3.3	3.3	100.0
TOTAL	30	100.0	100.0	

TABLE 41
POSTTEST FREQUENCIES

Treatment 3 (C)

Performance Score	Absolute Freq	Relative Freq (PCT)	Adjusted Freq (PCT)	Cum Freq (PCT)
2.	1	3.3	3.3	3.3
3.	2	6.7	6.7	10.0
4.	1	3.3	3.3	13.3
5.	6	20.0	20.0	33.3
6.	5	16.7	16.7	50.0
7.	4	13.3	13.3	63.3
8.	5	16.7	16.7	80.0
9.	1	3.3	3.3	83.3
10.	1	3.3	3.3	86.7
11.	1	3.3	3.3	90.0
12.	2	6.7	6.7	96.7
13.	1	3.3	3.3	100.0
TOTAL	30	100.0	100.0	

TABLE 42
PERFORMANCE IQ FREQUENCIES

Treatment 3 (C)

Performance IQ	Absolute Freq.	Relative Freq. (PCT)	Adjusted Freq. (PCT)	Cum Freq. (PCT)
86.	2	6.7	6.7	6.7
90.	1	3.3	3.3	10.0
100	11	36.7	36.7	46.7
102	3	10.0	10.0	56.7
104.	1	3.3	3.3	60.0
105	2	6.7	6.7	66.7
106.	1	3.3	3.3	70.0
107.	2	6.7	6.7	76.7
108	2	6.7	6.7	83.3
114.	5	16.7	16.7	100.0
TOTAL	30	100.0	100.0	

TABLE 43
VERBAL IQ FREQUENCIES

Treatment 3 (C)

Verbal IQ	Absolute Freq.	Relative Freq.(PCT)	Adjusted Freq (PCT	Cum Freq (PCT)
77	1	3.3	3.3	3.3
87	1	3.3	3.3	6.7
90	1	3.3	3.3	10.0
94	1	3.3	3.3	13.3
99	1	3.3	3.3	16.7
100.	5	16.7	16.7	33.3
101	2	6.7	6.7	40.0
102	3	10.0	10.0	50.0
104	1	3.3	3.3	53.3
105	3	10.0	10.0	63.3
106.	1	3.3	3.3	66.7
107.	3	10.0	10.0	76.7
108	1	3.3	3.3	80.0
109	1	3.3	3.3	83.3
112	1	3.3	3.3	86.7
114	2	6.7	6.7	93.3
122	1	3.3	3.3	100.0
TOTAL	30	100.0	100.0	

TABLE 44
FULL SCALE IQ FREQUENCIES

Treatment 3 (C)

IQ	Absolute Freq	Relative Freq (PCT)	Adjusted Freq (PCT)	Cum Freq (PCT)
80.	1	3.3	3.3	3.3
87.	1	3.3	3.3	6.7
89.	1	3.3	3.3	10.0
99.	1	3.3	3.3	13.3
100.	4	13.3	13.3	26.7
101.	2	6.7	6.7	33.3
102.	2	6.7	6.7	40.0
103.	3	10.0	10.0	50.0
104	1	3.3	3.3	53.3
105	4	13.3	13.3	66.7
107	1	3.3	3.3	70.0
109.	4	13.3	13.3	83.3
110.	2	6.7	6.7	90.0
111.	1	3.3	3.3	93.3
119.	1	3.3	3.3	96.7
120.	1	3.3	3.3	100.0
TOTAL	30	100.0	100.0	

TABLE 45
TYPE OF FREQUENCIES

Treatment 3 (C)

Code	Absolute Freq	Relative Freq.(PCT)	Adjusted Freq (PCT)	Cum Freq (PCT)
Reflective	10	33.3	33.3	33.3
Impulsive	11	36.7	36.7	70.0
Other	9	30.0	30.0	100.0
TOTAL	30	100.0	100.0	

TABLE 46
ERROR SCORE FREQUENCIES

Treatment 3 (C)

Error Score	Absolute Freq.	Relative Freq (PCT)	Adjusted Freq (PCT)	Cum Freq (PCT)
2.	1	3.3	3.3	3.3
3.	1	3.3	3.3	6.7
4.	1	3.3	3.3	10.0
7.	5	16.7	16.7	26.7
8.	3	10.0	10.0	36.7
9.	3	10.0	10.0	46.7
10.	2	6.7	6.7	53.3
11.	2	6.7	6.7	60.0
12.	4	13.3	13.3	73.3
13.	2	6.7	6.7	80.0
15.	1	3.3	3.3	83.3
16.	1	3.3	3.3	86.7
17.	1	3.3	3.3	90.0
19.	1	3.3	3.3	93.3
20.	2	6.7	6.7	100.0
TOTAL	30	100.0	100.0	

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BIOGRAPHICAL SKETCH

Born in St. Augustine, Florida on March 12, 1940, Albert W. Strickland, III then moved to Miami, Florida with his parents, Martha and Albert W. Strickland, Jr. He spent his early childhood years and high school years in Miami, graduating from Miami Jackson High School in 1958.

He attended Georgia Technological University in 1958 and 1959 completing eighty semester hours in Electrical Engineering before transferring to the University of Florida where he earned his Bachelor of Science in Science Education in 1963. Then, he completed a Master's degree in Science Education with majors in math and physics. He completed 24 semester hours of graduate work in nuclear physics at the University of Notre Dame before transferring to the University of Florida to complete work on a Doctorate in Science Education.

His teaching experience includes six years of public school experience during which time he received an outstanding national award for teaching physics. He has performed duties of Supervisor of Science for the Alachua County school system and teaching science at Santa Fe Community College.

During this time, the ages taught encompass children in preschool through adults in college.

Albert Wesley Strickland is not a newcomer to the field of Science Education. He has been active in NSTA for over twelve years and has delivered several papers to meetings of various science associated professional organizations and, in addition, has had seven publications in various professional journals.

He is currently a member of The National Science Teachers Association and a member of The National Association of Research in Science Teaching, American Educational Research Association, and Phi Delta Kappa.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy

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August, 1976

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